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DEVELOPMENT DOCUMENT FOR EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS FOR THE APPLE, CITRUS AND POTATO PROCESSING SEGMENT OF THE CANNED AND PRESERVED FRUITS AND VEGETABLES POINT SOURCE CATEGORY

ENVIRONMENTAL PROTECTION AGENCY

MARCH 1974

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Effluent limitations guidelines are set forth for the degree of effluent reduction attainable through the application of the "Best Practicable Control Technology Currently Available" and the "Best Available Technology Economically Achievable" which must be achieved by existing point sources by July 1, 1977 and July 1, 1983, respectively. The "Standards of Performance for New Sources" set forth a degree of effluent reduction which is achievable through the application of the best available demonstrated control technology processes, operating methods or other alternatives.

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DEVELOPMENT DOCUMENT

for

EFFLUENT LIMITATIONS GUIDELINES

and

NEW SOURCE PERFORMANCE STANDARDS

for the

APPLE, CITRUS AND POTATO PROCESSING SEGMENT OF THE CANNED AND PRESERVED FRUITS AND VEGETABLES POINT SOURCE CATEGORY

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ABSTRACT

This document presents the findings of a study of the apple, citrus and potato processing segment of the canned and preserved fruits and vegetables industry for the purpose of developing waste water effluent limitation guidelines, Federal standards of performance for new sources in order to implement Section 304 (b) and 306 of the Federal Water Pollution Control Act Amendments of 1972 (the "Act"). The first phase of the study is limited to processors of apple products (except caustic peeled and dehydrated products), citrus products (except pectin and pharmaceutical products), and frozen and dehydrated potato products. Other commodities in S.I.C. 2033, 2034, and 2037 will be covered in a subsequent phase of this study.

Effluent limitations guidelines are set forth for the degree of effluent reduction attainable through the application of the "Best Practicable Control Technology Currently Available", and the "Best Available Technology Economically Achievable", which must be achieved by existing point sources by July 1, 1977, and July 1, 1983 ,respectively. The "Standards of Performance for New Sources" set forth the degree of effluent reduction which is achievable through the application of the best available demonstrated control technology, processes, or other alternatives.

The proposed regulations for July 1, 1977, require in-plant waste management and operating methods, together with the best secondary biological treatment technology currently available for discharge into navigable water bodies. This technology is represented by preliminary screening, primary treatment (potatoes only) and secondary biological treatment.

The recommended technology for July 1, 1983, and for new source performance standards, is in-plant waste management and preliminary screening, primary sedimentation (potatoes only), the best biological secondary treatment and disinfection (chlorination). In addition, more intensive biological treatment, and in a few cases final multi-media or sand filtration, may be required.

Land treatment systems such as spray or flood irrigation are effective and economic alternatives to the biological systems described above. When suitable land is available, land treatment is the preferred technology for July 1, 1977, for July 1, 1983, and for new source performance standards.

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SECTION I

CONCLUSIONS

The purpose of this report is to establish waste water effluent limitation guidelines for a segment of the canned and preserved fruit and vegetable industry. This segment consists of processors of the following products: apple products (except caustic peeled and dehydrated products); all citrus products (except pectin and pharmaceutical products); and all frozen and dehydrated potato products. A conclusion of this study is that this segment of the industry comprises five subcategories:

1. Apple Processing - Apple Juice
2. Apple Processing - Apple Products Except Juice
3. Citrus Processing - All Products
4. Potato Processing - Frozen Products
5. Potato Processing - Dehydrated Products

The major criteria for the establishment of the subcategories are the five day biochemical oxygen demand (BOD_5) and the suspended solids (SS) in the plant waste water. Subcategorization is required on the basis of raw materials processed and products produced. Evaluation of factors such as age, size and location of plant, production processes, and similarities in available treatment and control measures substantiate this industry subcategorization.

The wastes from all subcategories are amendable to biological treatment processes and several apple, citrus, and potato processing plants are able to achieve high levels of effluent reduction (BOD and suspended solids) through secondary biological treatment systems. The following plants are currently achieving at least the effluent reduction required through the application of Best Practicable Control Technology Currently Available: four apple plants including one juice plant; five citrus plants; and four frozen potato plants including one dehydrated plant (see Table 41). It is estimated that the costs of achieving these limits by all plants within this segment of the industry will be between \$17 and \$26 million (\$11.6 million for land and land treatment facilities included). Costs of \$17 million would increase the capital investment in the industry segment by about 1.4 percent and would increase the retail price of the products produced by approximately 2.3 percent.

With present secondary biological treatment systems without advanced treatment methods such as sand filtration, at least one apple, citrus and potato plant in each of the five subcategories is presently achieving the high levels of effluent reduction required by the application of the Best Available Control Technology Economically Achievable (see Table 41). It is estimated that the costs above those for 1977 for achieving the 1983 limits for all plants within this segment of the industry will be an additional $12 million. These costs would increase the capital investment by about 1.0 percent and the retail price of the products produced by approximately 1.6 percent.

It is concluded that land treatment is an effective and economical alternative where suitable and adequate land is available. Over forty apple, citrus, and potato processors utilize this technology to achieve minimal waste water discharge.

SECTION II

RECOMMENDATIONS

The waste water effluent reduction limitations attainable through the application of the Best Practicable Control Technology Currently Available are based on the performances of exemplary secondary biological systems treating apple, citrus or potato waste water. Best Practicable Control Technology Currently Available includes the following treatment components: for the apple juice and apple products (except juice) subcategories (except caustic peeled and dehydrated products) -- preliminary screening and secondary biological treatment; for the citrus products subcategory (except pectin and pharmaceutical products) -- cooling towers for weak cooling wastes and preliminary screening and secondary biological treatment for process waste waters; for the frozen and dehydrated potato products subcategories -- preliminary screening, primary sedimentation, and secondary biological treatment. Where sufficient quantities of suitable land are available, land treatment such as spray irrigation is an attractive alternative to biological treatment in order to achieve BPCTCA limitations.

Recommended BPCTCA guidelines are set forth in the following tabulation including maximum limitations for any one day and maximum limitations for the average of daily values for any period of thirty consecutive days;

Subcategory(1)	Effluent Characteristic	Maximum Daily Average		Maximum Thirty Day Ave.	
		kg/kkg	lb/T	kg/kkg	lb/T
Apple Juice	BOD5	0.60	1.20	0.30	0.60
	Suspended Solids	0.80	1.60	0.40	0.80
Apple Products (Except Juice)	BOD5	1.10	2.20	0.55	1.10
	Suspended Solids	1.40	2.80	0.70	1.40
Citrus Products	BOD5	0.80	1.60	0.40	0.80
	Suspended Solids	1.70	3.40	0.85	1.70
Potato Products (Frozen)	BOD5	2.80	5.60	1.40	2.80
	Suspended Solids	2.80	5.60	1.40	2.80
Potato Products (Dehydrated)	BOD5	2.40	4.80	1.20	2.40
	Suspended Solids	2.80	5.60	1.40	2.80

(1) For all subcategories pH should be between 6.0 and 9.0.

The waste water effluent reduction limitations attainable through the application of the Best Available Control Technology Economically Achievable are based on the performance of the best secondary biological system treating apple, citrus or potato waste water. For each subcategory Best Available Control Technology Economically Achievable includes Best Practicable Control Technology Currently Available plus additional secondary biological treatment and disinfection (chlorination). Advanced treatment such as sand filtration could also be used. Recommended waste water guidelines are set forth in the following tabulation:

Subcategory(1)	Effluent Characteristic	Maximum Daily Average		Maximum Thirty Day Ave.	
		kg/kkg	lb/T	kg/kkg	lb/T
Apple Juice	BOD_5	0.20	0.40	0.10	0.20
	Suspended Solids	0.20	0.40	0.10	0.20
Apple Products (Except Juice)	BOD_5	0.20	0.40	0.10	0.20
	Suspended Solids	0.20	0.40	0.10	0.20
Citrus Products	BOD_5	0.14	0.28	0.07	0.14
	Suspended Solids	0.20	0.40	0.10	0.20
Potato Products (Frozen)	BOD_5	0.34	0.68	0.17	0.34
	Suspended Solids	1.10	2.20	0.55	1.10
Potato Products (Dehydrated)	BOD_5	0.34	0.68	0.17	0.34
	Suspended Solids	1.10	2.20	0.55	1.10

(1) For all subcategories pH should be between 6.0 and 9.0.

(2) For all subcategories most probable number (MPN) of fecal coliforms should not exceed 400 counts per 100 ml.

The waste water effluent reduction limitations for new sources are the same as those attainable through the application of the Best Available Control Technology Economically Achievable. These limitations are possible because of the present availability of the treatment technology to attain this level of effluent reduction and because new source site selection can assure land availability for land treatment facilities (such as spray irrigation).

SECTION III

INTRODUCTION

PURPOSE AND AUTHORITY

On October 18, 1972, the Congress of the United States enacted the Federal Water Pollution Control Act Amendments of 1972. The Act in part required that the Environmental Protection Agency (EPA) establish regulations providing guidelines for effluent limitations to be achieved by "point sources" of waste water discharge into navigable waters and tributaries of the United States.

Specifically, Section 301 (b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which require the application of the Best Practicable Technology Currently Available as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which require the application of the Best Available Technology Economically Achievable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) of the Act. Section 306 of the Act requires the achievement by new sources of a federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish, within 1 year of enactment of the Act, regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the Best Practicable Control Technology Currently Available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable, including treatment techniques, process and procedure innovations, operation methods and other alternatives. The regulations proposed herein set forth effluent limitations based upon raw material used, products produced, manufacturing process employed, and other factors. The raw waste water characteristics for each subcategory were then identified. This included an analysis of (1) the source and volume of water used in the process employed and the sources of waste and waste waters in the plant; and (2) the constituents (including thermal) of all waste waters including toxic constituents and other constituents which result in taste, odor and color in water. The constituents of waste waters which should be subject to effluent limitations guidelines and standards of performance were identified.

The full range of control and treatment technologies existing within each subcategory was identified. This included an identification of each distinct control and treatment technology, including both in plant and end-of-process technologies, which are existent or capable of being designed for each subcategory. It also included an identification, in terms of the amount of constituents (including thermal) and the chemical, physical, and biological characteristics of pollutants, of the effluent level resulting from the application of each of the treatment and control technologies. The problems, limitations and reliability of each treatment and control technology, and the required implementation time was also identified. In addition, the non-water quality environmental impact, such as the effects of the application of such technologies upon other pollution problems, was also identified. The energy requirements of each of the control and treatment technologies were identified as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated in order to determine what levels of technology constituted the "Best Practicable Control Technology Currently Available" and the "Best Available demonstrated control technology, processes, operating methods, or other alternatives". In identifying such technologies, various factors were considered. These included the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impact (including energy requirements) and other factors.

DATA SOURCES

The segment of the Canned and Preserved Fruits and Vegetables Industry category selected for this phase I effort includes S.I.C. codes 2033, 2034, and 2037 for apple processors (except caustic peeled and dehydrated products), citrus processors (except pectin and pharmaceutical products), and potato processors (frozen and dehydrated products). The remaining fruit and vegetable processors in those S.I.C. codes will be covered in a later phase of this study. The data and recommended effluent guidelines contained in this document were developed from information derived from a number of sources. These sources included review and evaluation of available literature, the results of EPA research, development and demonstration projects, consultation with qualified experts in the field, correspondence with industry associations, EPA Permit data, data from states and municipalities, and correspondence with individual processors and on-site visits and interviews. Visits were made to, and historic data reviewed at, more than 130 processing plants; sampling and analysis were carried out at 38 of these plants. The principal source of raw waste and treated effluent data was current and historical information gathered from individual plants. Visits were made to, and historical data reviewed from more than 40 apple processing plants, more than 50 citrus processing plants and more than 40 potato processing plants. Appendix C contains the format for this collected data. Sampling data was gathered from 13 apple plants, 13 citrus plants, and 12 potato plants. The purpose of this data was to supplement or confirm data supplied by the processor or other sources. The success of this effort is reflected in Section V with the computation of industry raw waste loads. Sixty-two different plants actually contributed to the computation. All references used in developing the guidelines for effluent limitations and standards of performance for new sources reported herein are included in Supplement B to this document. A listing of apple plants (AP-101 to AP-142), citrus plants (CI-101 to CI-149), and potato plants (PO-101 to PO-136) used in this study is presented in Appendix A.

GENERAL DESCRIPTION OF INDUSTRY

Apples

The apple was introduced into the western part of the country in the middle of the nineteenth century. Apples cannot be grown satisfactorily in the southern part of the United States because of climatic conditions. Because the fruit requires a relatively constant, cool temperature, production has been concentrated in relatively few states. For the last three years, the average national apple production has been almost three million kilo-kilograms. About 70 percent of the total production are obtained from six leading states (Table 1).

In 1971, there were 164 apple processing plants located in 28 states (Figure 1). In that year total production was 2.8 million kilo-kilograms. Of this total, about 57 percent went for fresh pack and 43 percent for processing. Of the total crop, apple sauce and other canning took 18 percent; frozen products 3 percent, and dried products less than 2 percent. Other products, which consist mostly of apple juice and vinegar, accounted for over 20 percent of the total crop (Table 2). By geographic distribution, about 50 percent of the processed apple products is obtained from the states of Michigan, New York and Pennsylvania, while the states of Washington, Virginia and California each contributed about 11 percent. The remaining 17 percent of processed apple products is obtained from 22 states, where most of the processing is concentrated in the production of vinegar.

TABLE 1

APPLES - PRODUCTION BY STATES IN U.S. 1971

Location	No. of Processing Plants	Fresh Pack		Processed	
		M kg	M lbs.	M kg	M lbs.
Michigan	35	136.2	300.0	190.7	420.0
New York	28	160.3	353.0	259.7	572.0
California	21	50.8	112.0	130.8	288.0
Washington	15	415.9	916.0	128.9	284.0
Pennsylvania	9	84.0	185.0	145.3	320.0
Virginia	7	89.0	196.0	128.9	284.0
Other States	49	650.7	1,433.3	202.8	446.8
TOTAL	164	1,586.9	3,495.3	1,187.1	2,614.8

Source: *Agricultural Statistics* - 1972
U.S. Department of Agriculture

FIGURE 1 NUMBER OF OPERATING APPLE PROCESSING PLANTS IN UNITED STATES

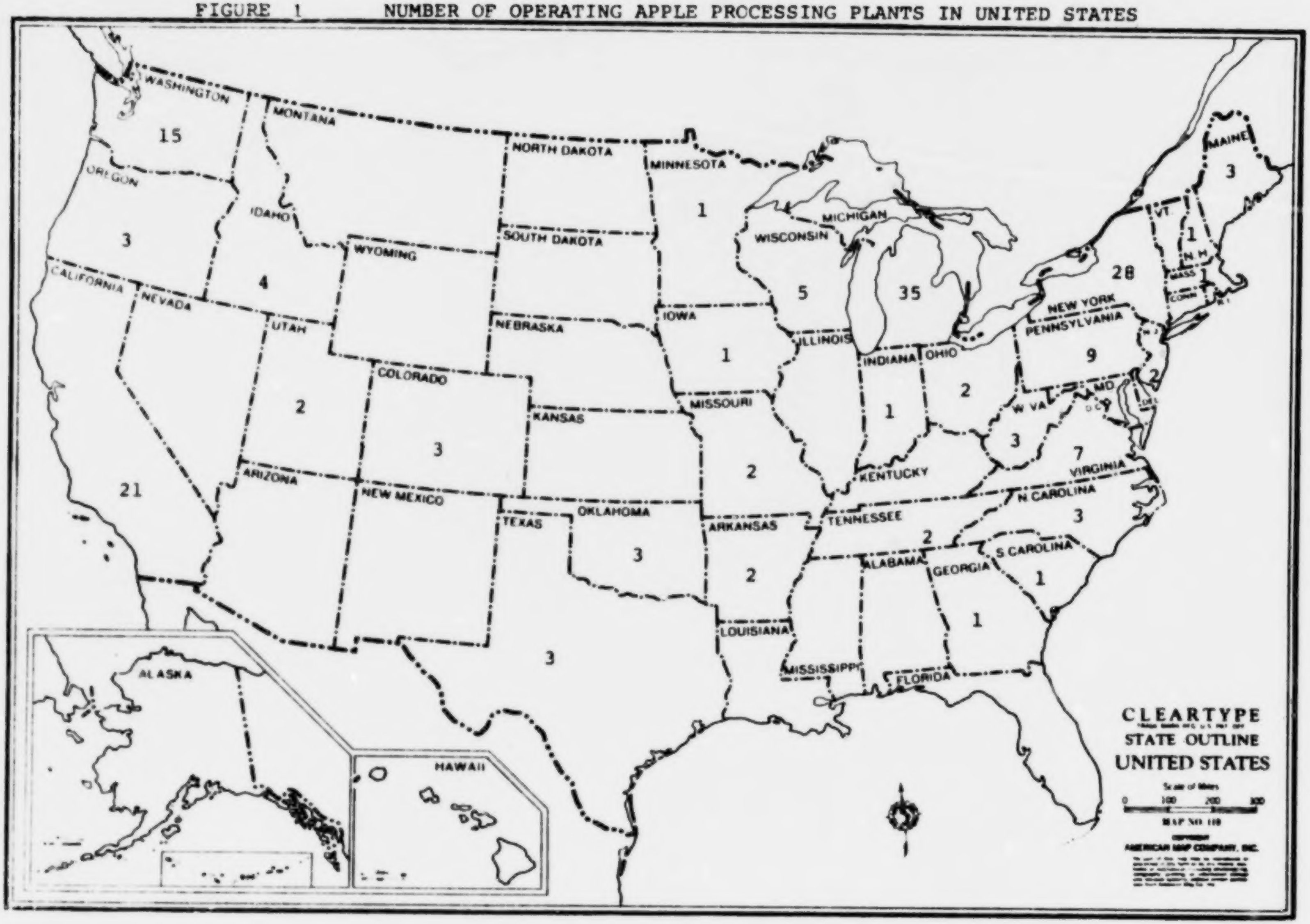

WASHINGTON
15
MONTANA
OREGON
3
IDAHO
4
CALIFORNIA
21
NEVADA
UTAH
2
WYOMING
ARIZONA
COLORADO
3
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
3
TEXAS
3
MINNESOTA
1
IOWA
1
MISSOURI
2
ARKANSAS
2
LOUISIANA
WISCONSIN
5
MICHIGAN
35
ILLINOIS
INDIANA
1
OHIO
2
KENTUCKY
TENNESSEE
2
MISSISSIPPI
ALABAMA
GEORGIA
1
FLORIDA
S CAROLINA
1
N CAROLINA
3
VIRGINIA
7
W VA
3
MD
D C
DEL
PENNSYLVANIA
9
2
NEW YORK
28
VT.
N. H.
1
MASS
CONN
R I
MAINE
3
ALASKA
HAWAII
CLEARTYPE
STATE OUTLINE
UNITED STATES
Scale of Miles
0
100
200
300
MAP NO 110
AMERICAN MAP COMPANY, INC.

TABLE 2

APPLES - FRESH PACK AND MANUFACTURED PRODUCTS IN U.S. 1969-71

ITEM	1969		1970		1971	
	M kg	M lbs.	M kg	M lbs.	M kg	M lbs.
Fresh	1,682.9	3,707.0	1,597.9	3,519.5	1,586.9	3,495.3
Canned	634.8	1,398.3	539.9	1,189.3	496.4	1,093.5
Dried	127.2	280.2	84.9	187.0	44.2	97.4
Frozen	94.3	207.6	82.1	180.8	77.3	170.3
Other	509.5	1,122.2	552.7	1,217.3	569.1	1,253.6
TOTAL	3,065.3	6,751.8	2,857.4	6,293.9	2,774.0	6,110.1

Source: Agriculture Statistics - 1972, U. S. Department of Agriculture

Consumption of canned apples and apple sauce has remained almost constant over the last ten years. Frozen and dried products have also failed to exhibit any real growth. Only apple juice products show signs of increased consumer acceptance, with larger volumes of domestic apples channeled to this outlet and increased juice imports apparently finding a ready market. Trade reports indicate that apples are being used increasingly in the production of wines.

Product Classification

The U. S. Bureau of Census classifies the apple processing industry within Standard Industrial Classification (SIC) 203, Canned and Preserved Fruits and Vegetables. A detailed list of product codes applicable to the apple processing industry is contained in Appendix B.

Growth Projections

The processing of apples will continue to be concentrated in the six leading states of Michigan, New York, Pennsylvania, Washington, Virginia and California. Statistics covering the last few years indicate that the production of apples in the eastern United States increased slightly; central U. S. production remained almost constant and that of the western states (predominately fresh pack) was down slightly. Increased demand for apple juice is expected to exert an upward pressure on apple production. The new factor in the apple industry is the rapidly increasing use of apples for the production of wine. If this trend continues, a substantial tonnage of apples will be required to satisfy this market sector.

The technology of harvesting apples and processing them has been relatively static for a number of years. Some of the factors that are bringing about changes in the industry are:

1. Mechanical harvesting is increasing in order to reduce labor costs.

2. Concern over waste generation and treatment has resulted in interest in such waste reduction techniques as dry caustic peeling and hot gas blanching.

3. Because of improvements in controlled atmosphere storage, the season for processing apples will become progressively longer.

It is estimated that about 1.5 million kilo-kilograms of apples will be processed by 1977.

Citrus

Citrus is the largest fruit crop in the United States, with a farm value exceeding $400 million annually in recent years. Primarily because of climate, citrus production is concentrated in Florida, California, Arizona and Texas (Table 3). During the 1950's and early 1960's production was low. Beginning in 1963, production increased steadily because of improvements in technology, management and cultural practices. Since 1950, Florida citrus output has more than doubled and now represents about three-fourths of total U. S. production. California citrus production has fallen to 18 percent of total output in recent years as land has been converted to housing and other uses. Arizona and Texas, together, produced approximately 5 percent of domestic citrus output.

There are 97 citrus processing plants in 14 states (Figure 2). Florida has 53 plants, representing more than 54 percent of the total (Table 3). During the last two decades, there has been a striking shift in the use of citrus from fresh to processed forms. This mainly reflects the sharp increase in the use of Florida production for processing. In the 1971 season, Florida packed 97 percent of the citrus products produced in the United States. Marketing patterns favor fresh citrus in Arizona, California and Texas. But even in these states the proportion of citrus used fresh has declined.

Processed forms include frozen, chilled and canned. Commercial introduction of frozen concentrated citrus juices in the mid - 1940's stimulated a rapid and dramatic increase in processing of Florida citrus. Since that time, the rate of increase in citrus used for frozen concentrated citrus juices has been dramatic. The proportion of the Florida citrus crop dedicated to juice production has increased from 6 to 70 percent. The increased volume of citrus used for chilled citrus products has also had an impact on processing use. The proportion of the Florida citrus used for chilled citrus products has increased from 3 percent in 1945 to 14 percent in the 1971 season. In contrast to the sharp increase in utilization of citrus for frozen concentrated and chilled products, the volume of Florida citrus used for canning has decreased sharply.

TABLE 3

CITRUS - U.S. PRODUCTION & PROCESSING BY STATE - 1970-72

LOCATION	No. of Processing Plants	1970		1971		1972	
		1,000 kkg	1,000 Tons	1,000 kkg	1,000 Tons	1,000 kkg	1,000 Tons
FLORIDA	53						
Oranges -Production		5,621	6,197	5,808	6,404	5,592	6,165
-Processed		5,079	5,600	5,238	5,775	5,134	5,660
Grapefruit-Production		1,442	1,590	1,563	1,823	1,812	1,998
-Processed		891	983	1,077	1,187	1,155	1,273
Tangerines-Production		130	143	160	176	138	152
-Processed		26	29	44	49	42	46
Temples -Production		212	234	204	225	217	239
-Processed		97	107	113	125	143	158
Limes -Production		26	29	111	122	160	176
Processed		13	14	44	49	82	90
Tangelos -Production		102	113	211	233	178	196
-Processed		45	50	64	71	56	62
CALIFORNIA	20						
Oranges -Production		1,327	1,463	1,275	1,406	1,473	1,624
-Processed		425	469	400	441	517	570
Grapefruit-Production		155	171	149	164	151	166
-Processed		73	81	65	72	73	81
Lemons -Production		438	483	458	505	469	517
-Processed		161	178	167	184	196	216
Tangerines-Production		25	28	48	53	21	23
-Processed		12	13	15	16	8	9
ARIZONA	2						
Oranges -Production		158	174	122	134	167	184
-Processed		75	83	76	84	98	108
Grapefruit-Production		92	101	73	81	73	81
-Processed		41	45	53	58	36	40
Lemons -Production		97	107	108	119	106	117
-Processed		51	56	64	71	61	67
Tangerines-Production		12	13	14	15	19	21
-Processed		4	4	5	6	6	7

(Continued)

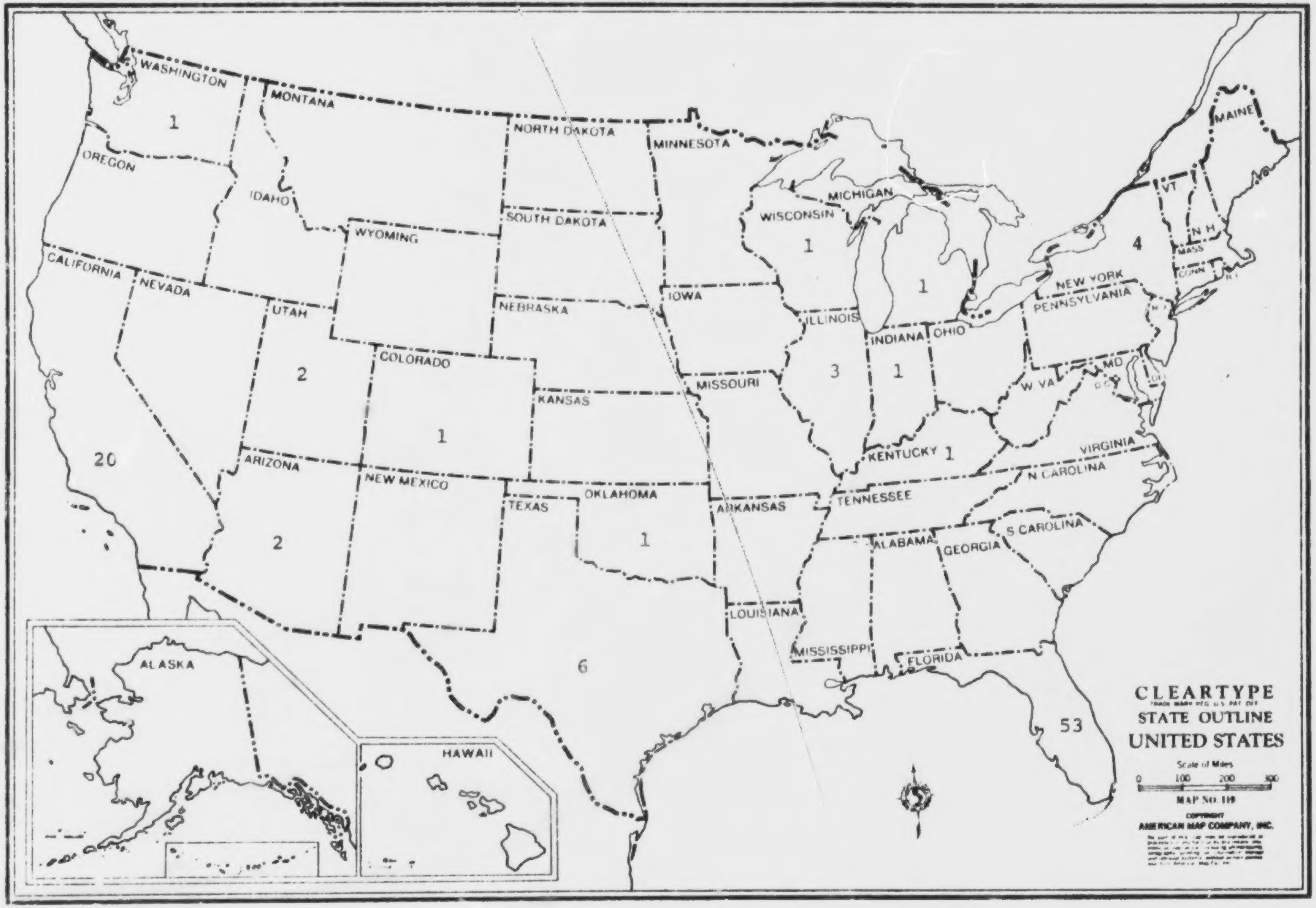
TABLE 3
CITRUS- U.S. PRODUCTION & PROCESSING BY STATE - 1970-72
(Continued)

LOCATION	No. of Processing Plants	1970		1971		1972	
		1,000 kkg	1,000 Tons	1,000 kkg	1,000 Tons	1,000 kkg	1,000 Tons
TEXAS	6						
Oranges -Production		171	189	253	279	237	261
-Processed		73	81	125	138	131	144
Grapefruit-Production		294	324	366	404	334	368
TOTAL U.S.	97						

Source: 1. Citrus Fruits by States,
Statistical Reporting Service,
U.S. Department of Agriculture,
October 1972, Fr Nt 3-1 (10-72)

2. The Directory of Canning, Freezing,
Preserving Industry, 1972-1973,
by Edward E. Judge & Son, Inc.

FIGURE 2 CITRUS PROCESSING PLANTS


WASHINGTON
1
MONTANA
NORTH DAKOTA
MINNESOTA
MAINE
OREGON
IDAHO
MICHIGAN
VT
N H
WISCONSIN
1
SOUTH DAKOTA
WYOMING
4
MASS
CONN
R I
CALIFORNIA
NEVADA
1
NEW YORK
UTAH
NEBRASKA
IOWA
PENNSYLVANIA
ILLINOIS
INDIANA
OHIO
COLORADO
2
3
1
MD
MISSOURI
W VA
D C
KANSAS
1
20
KENTUCKY
1
VIRGINIA
ARIZONA
NEW MEXICO
N CAROLINA
TEXAS
OKLAHOMA
ARKANSAS
TENNESSEE
S CAROLINA
1
2
ALABAMA
GEORGIA
LOUISIANA
MISSISSIPPI
FLORIDA
ALASKA
6
CLEARTYPE
TRADE MARK REG U S PAT OFF
STATE OUTLINE
UNITED STATES
53
HAWAII
Scale of Miles
0
100
200
300
MAP NO. 119
COPYRIGHT
AMERICAN MAP COMPANY, INC.

Annual per capita consumption of citrus, fresh and processed combined on a fresh weight equivalent basis, shows an erratic trend during the last two decades. In general, fresh consumption has decreased, but processed citrus consumption has increased, led by a sharp increase in frozen items. Per capita consumption of frozen concentrated citrus juices increased from 6.8 to 16.3 kg (15 to 36 lbs) over the past two decades.

Chilled citrus juice consumption increased from 0.8 to 3.8 kg (1.7 to 8.5 lbs) over the same period. Because of the rapid rise in frozen and chilled juice consumption, canned citrus juice consumption decreased substantially from 5.2 to 3.2 kg (11.5 to 7 lbs). Consumption of canned orange sections and citrus salad combined has also been erratic and has accounted for less than 2 percent of processed per capita consumption. However, consumer demand for processed citrus appears to be increasing.

Product Classification

The citrus processing industry is classified under SIC Group No. 203, Canned and Preserved Fruits and Vegetables. A detailed list of product codes covering the products of the citrus processing industry is contained in Appendix B.

Growth Projection

Citrus for fresh use will continue to be grown in three western states. However, because of the increasing demand for frozen concentrated juice, it is expected that more citrus grown in California and Texas will be processed. Florida will continue to be the leading state for processed citrus products and production can be expected to expand substantially with time to meet the rising demand.

Chilled citrus juices cannot be made from stored fruit but must be processed immediately after harvesting. For this reason, the processing season is short and there is little incentive to increase plant size. In the production of frozen concentrated juice, however, the processing season is extended through the use of stored concentrate and there is a trend toward processing plants of larger capacity. Processing techniques have been relatively static in recent years although the pressure for water pollution control has resulted in some changes. Waste heat evaporators are being introduced to treat odor-causing wastes.

It is estimated that the quantity of citrus processed will increase to 9 million kilo-kilograms by 1977.

Potatoes

The potato was first introduced into the Northern American continent from England in 1621. During the 18th and 19th centuries the potato became a significant source of food in Europe, but because of its short storage life it was not completely utilized. During the latter half of the 18th century there was experimentation with various types of dried potatoes. However, little was accomplished in this direction until World War I when a number of dehydrated potato products were manufactured for military use. Since that time, potatoes have ranked high among crops utilized chiefly for food.

The average annual United States potato production over the last three years was approximately 14 million kkg (315 million hundred weights). Two-thirds of this total was obtained from seven leading states (Table 4). About 40 percent of total national potato production is used for processing. In 1972, there were 112 canned and frozen potato processing plants in 31 states (Figure 3).

Demand for potatoes and potato products has changed markedly over the past decade. Annual per capita consumption increased from 47.2 kg (108.4 lbs) in 1961 to 54.12 kg (119.2 lbs) in 1971. The increase in consumption is credited entirely to processed use. In contrast, per capita consumption of fresh potatoes has fallen substantially. Frozen french fries have paced the growth of processed potato products. Frozen products now account for about 45 percent of all potatoes used for processing.

Dehydrated potatoes account for about 20 percent of all potatoes used for processing. Per capita consumption of canned potatoes has remained almost constant at about 5 percent and the production of potato chips account for 30 percent of potatoes.

Product Classification

The potato processing industry is classified under SIC Groups 203, Canned and Preserved Fruits and Vegetables, 204, Grain Mill Products, and 209, Miscellaneous Food Preparations and Kindred Products. A detailed list of product codes within the foregoing groups is presented in Appendix B.

Growth Projections

Potato production in the 1960's trended generally upward due to larger output of North Dakota, Idaho and Washington. Demand for potatoes will increase in the years ahead due to population growth and continued increases in demand for processed convenience products. Projections indicate that processed potato products will account for approximately 75 percent of total

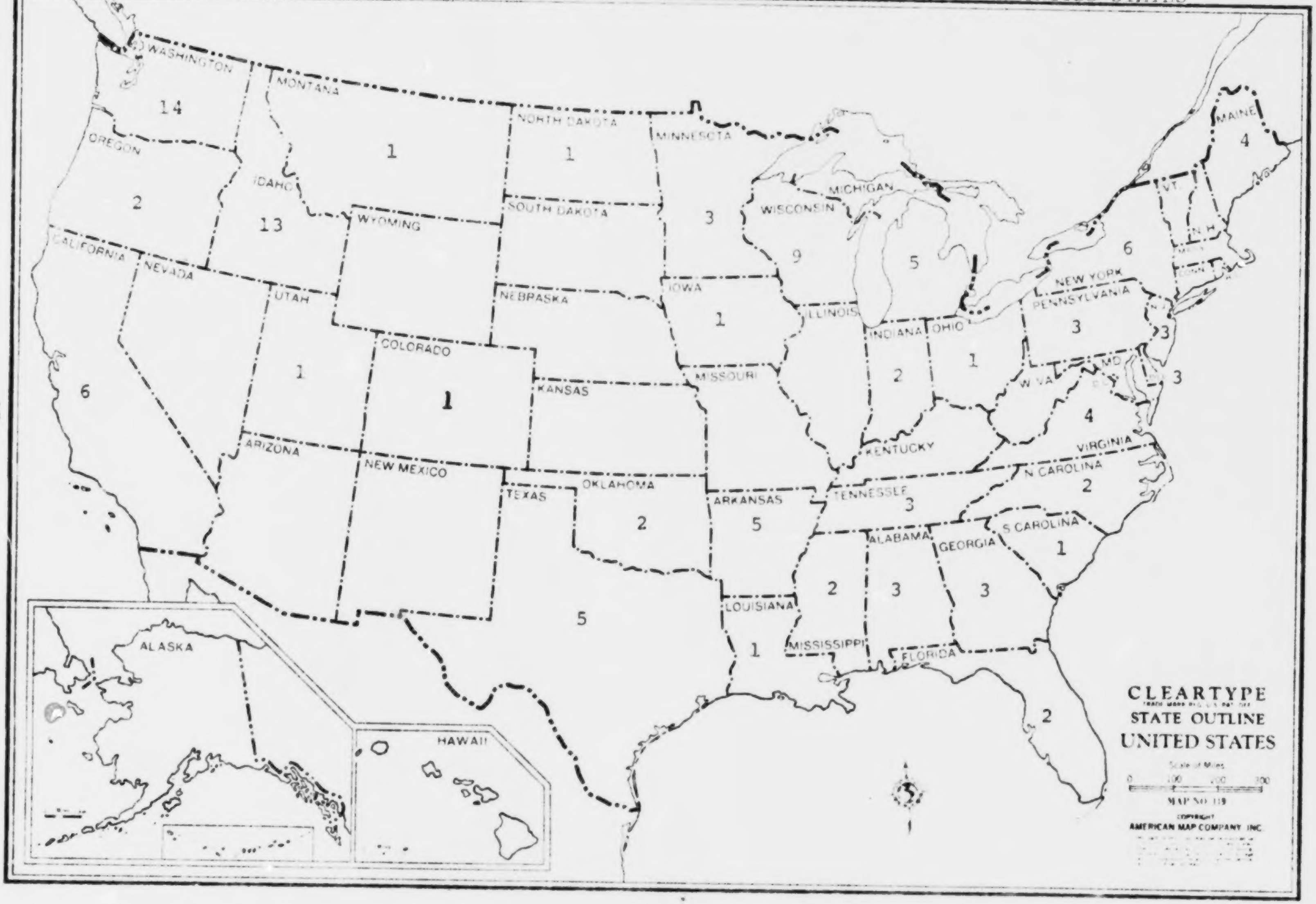
TABLE 4

POTATOES - PRODUCTION BY STATES IN U.S. 1969-71

Location	No. of Processing Plants	1969		1970		1971	
		1,000 kkg	M lbs.	1,000 kkg	M lbs.	1,000 kkg	M lbs.
Idaho	13	3,172.1	6,987.0	3,389.6	7,466.0	3,443.6	7,585.0
Maine	4	1,593.5	3,510.0	1,620.8	3,570.0	1,713.9	3,775.0
Washington	14	1,352.7	2,979.6	1,525.0	3,359.0	1,367.0	3,011.0
California	6	1,320.8	2,909.3	1,351.1	2,976.0	1,198.6	2,640.0
North Dakota	1	733.6	1,615.9	790.0	1,740.0	837.4	1,844.5
Minnesota	3	702.6	1,547.5	607.9	1,339.0	759.3	1,672.5
New York	6	770.6	1,697.4	770.8	1,697.7	689.2	1,518.0
Wisconsin	9	563.4	1,241.0	591.5	1,302.8	598.5	1,318.3
Colorado	1	528.6	1,164.3	598.4	1,318.0	469.0	1,033.0
Michigan	5	399.3	879.6	446.5	983.4	374.1	824.1
Pennsylvania	3	354.6	781.0	375.9	828.0	370.7	816.5
Other States	47	2,668.5	5,877.7	2,714.4	5,978.9	2,531.2	5,575.4
TOTAL	112	14,160.4	31.190.3	14,781.7	32,558.8	14,350.2	31,608.3

Source: Agricultural Statistics, 1972
U.S. Department of Agriculture

FIGURE 1 POTATOES - NO. OF OPERATING CANNED & FROZEN PLANTS IN UNITED STATES


WASHINGTON 14
OREGON 2
CALIFORNIA 6
IDAHO 13
NEVADA
MONTANA 1
WYOMING
UTAH 1
COLORADO 1
ARIZONA
NEW MEXICO
NORTH DAKOTA 1
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA 2
TEXAS 5
MINNESOTA 3
IOWA 1
MISSOURI
ARKANSAS 5
LOUISIANA 1
WISCONSIN 9
ILLINOIS
MICHIGAN 5
INDIANA 2
OHIO 1
KENTUCKY
TENNESSEE 3
MISSISSIPPI 2
ALABAMA 3
GEORGIA 3
FLORIDA 2
S CAROLINA 1
N CAROLINA 2
VIRGINIA 4
W VA
MD
NEW YORK 6
PENNSYLVANIA 3
N.J. 3
3
VT.
N H
MAINE 4
ALASKA
HAWAII
CLEARTYPE
STATE OUTLINE
UNITED STATES
Scale of Miles
0 100 200 300
MAP NO. 119
COPYRIGHT
AMERICAN MAP COMPANY, INC.

food use of potatoes by 1980. Frozen potato products are expected to remain the leading item among the processed forms. Consumption of dehydrated potatoes will increase only slightly, while fresh potato consumption is projected to continue its long downward trend to a per capita consumption in the range of 15.9 kg to 18.2 kg (35 to 40 lbs).

The size of processing plants has increased in recent years, and this trend is expected to continue under the pressures of competition and increased complexity of manufacturing and marketing operations. Except for the introduction of dry caustic peeling, potato processing techniques have not changed substantially in recent years. Increased water pollution control activity is expected to have an impact on processing plants in the form of better in-plant control of waste generation and water consumption.

PROFILE OF MANUFACTURING PROCESSES

Apples

General

There are three basic products which are made from apples in large volume: a) slices, b) sauce, and c) juice (cider). Other products such as dehydrated apple pieces, spiced apple rings, spiced whole apples and baked apples, are all produced in much lesser volume and are usually produced in conjunction with one of the major products (slices, sauce, juice).

The apple harvest begins in some locations in midsummer and in other areas extends through the fall season. In recent years, the processing season which begins with the harvest of apples has been extended well beyond the harvest period by placing an increased amount of apples in controlled atmosphere storage. Consequently, when there is an adequate or abundant supply of apples, most large processors can, and usually do, operate their plants over a seven to eight month period.

During the early fall, at the peak of the harvest season, many of the apple processors will operate their plants on a two or three shift, five-day-per-week basis. However, when the apples are no longer being delivered directly from the field, the processor usually operates his plant on one shift for processing, followed by a cleanup shift.

Later in the operating year, depending upon the availability of apples, the processor may operate his plants on an even more sporadic schedule.

Processing Steps

Apple processing usually includes storage, washing and sorting, peeling and coring, slicing, chopping, juice extracting, dehydrating, deaerating and cooking. End products in approximate order of pack size are apple sauce, apple juice, and frozen and canned apple slices.

CA (Controlled Atmosphere) Storage - The proper ripeness of the apple directly reflects on the final product quality. An overripe apple will cause a poor flavor in the product, while an unripe apple will produce an off-color and a poor flavor in the product. In the controlled atmosphere storage, the temperature and relative humidity of the recirculated air is closely controlled. To meet the demands of the fresh market, the apples are periodically removed from storage, graded or sorted, and the proper quality fruit is directed to the processor.

Washing and Sorting - Apples that are received from either the field or CA storage must be thoroughly washed to remove all residues that may be on the fruit. To ensure removal, in some instances, chemicals or detergents are added to the wash water. The water, or a large portion of it, is often reused within the washing system to conserve wash water and reduce the volume of waste effluent leaving the processing plant. This can be accomplished by (1) periodically draining the washing system, or (2) regulating the overflow and makeup water addition to the system.

The purpose of sorting is to remove the smaller, misshapened or inferior fruit and redirect this fruit into products, such as juice, which can accept the lower-quality raw material.

Peeling and Coring - Mechanical peeling is the most popular method for removing the apple peel. This is particularly true where a sliced product is being produced. The mechanical peeler can be adjusted to remove a greater or lesser percentage of the imperfections in the fruit. The peel and core particles are often collected and used in the production of either juice or vinegar stock. In a mechanical peeling operation, the peel and core fraction represents approximately 35 percent of the apple processed.

Steam and caustic peeling are also used by apple processors; however, these methods are more successful in manufacturing a sauce product than with a sliced product. The peel loss is not as great in caustic peeling when compared to mechanical peeling. It is often desirable to remove a greater percentage of the peel in the manufacture of slices or sauce to ensure the complete elimination of surface imperfections.

The peel removed by caustic treatment cannot be utilized in cider manufacture, but the core, if properly handled, is still suitable for use as a raw material for cider processing. In the steam and caustic type peelers, the final removal is accomplished by a rotary washer using water sprays. A few of the apple processors have installed abrasive type scrubbers to replace the conventional rotary washers. The peeling and coring operations represent a major source of waste to the apple processing industry and, wherever possible, operating procedures should be used to minimize the contact between cut portions and wash water to reduce the amount of soluble constituents lost to the waste effluent. A certain amount of water is still required to prevent browning of the apple particles.

Slicing - If fresh apple slices are the end product, these slices can be cut after the core has been removed or simultaneously as the apple is being cored. The apple slices are washed, graded and inspected before packaging as fresh apple slices or further processed into dehydrated, frozen, or canned products.

Deaerating - If the apple slices are to be either frozen or canned, they are deaerated by immersion in a brine solution while a vacuum is pulled on the tank. The brine is then drained from the slices which are then either frozen and packaged or cooked prior to canning.

Canning - In the canning of apple slices, the slices are steam blanched or pre-heated, placed into the can while still hot, sealed, and further cooked to assure preservation.

Product Styles

Slices - Apple slices are processed from solid fresh apples of proper maturity and proper ripeness. After the apples are washed, sorted, peeled and cored, they are sliced by cutting segments longitudinally and radially from the core centerline. The slices are further inspected and packaged for immediate use as a fresh product, or they can be dehydrated in a tunnel drier and packaged as dehydrated apple slices. If either a frozen or canned product is required, the apples are deaerated prior to processing.

Sauce - Apple sauce is prepared from comminuted or chopped apples which may or may not have been previously peeled and cored. In addition to removal of the peel and core, good manufacturing practice dictates the separation of bruised apple particles, carpel tissue and other coarse hard extraneous materials. The apples are washed, sorted, cored and peeled in a manner identical to the manufacture of slices. Flavor and consistency are adjusted with water and sugar, generally in the form of liquid sugar.

The cored apple is sliced or diced into small pieces, cooked and, while still hot, passed through a finisher for removal of any large foreign particles. The hot apple sauce from the finisher is inspected, and any remaining foreign particles are removed prior to canning and cooling.

Apple Juice (Cider) - Apple juice (cider) is an unfermented liquid prepared from 1) fresh whole sound apples or 2) apple pieces such as cores and peelings obtained from either a slice or a sauce manufacturing operation. If whole apples are used, they are washed and comminuted before pressing. The pressed juice is screened to remove large foreign particles and frequently clarified by diatomaceous earth pressure filtration. The apple juice is then heated to assure preservation of the product in hermetically sealed containers.

A concentrated apple juice can be made from the single-strength juice through the removal of water (evaporation). The concentrate is stored or packaged in bulk containers (55-gallon drums). In the manufacture of apple juice (cider), it is not customary to either peel or core the apple. Consequently, there is not the large amount of waste being discharged at this portion of the process.

Vinegar stock is made in a manner similar to the pressing of apple cider. However, the vinegar stock is made from poor quality apples. It is never clarified to the same degree as apple cider; however, it is usually concentrated prior to bulk shipment in tank cars to the vinegar processing plant.

Citrus

General

The citrus industry is concentrated in two areas of the U.S. The major portion, approximately 80 percent of the industry, is located in Florida and the remaining 20 percent is located in the southwestern part of the U.S. (California, Arizona and Texas). Oranges, grapefruit, lemons, tangerines (mandarins) and limes, ranked in the order of importance, are all processed into citrus products and co-products such as juice, dried peel, oil, segments and molasses. A few citrus processors also manufacture such items as pectin, flavorings, essence, pharmaceuticals, etc. Citrus juice, single-strength and concentrated, is by far the major product of the citrus processing industry.

Citrus is both harvested and processed only in four states; Florida, California, Texas and Arizona. In the eastern area, Florida, 90 percent of all fruit picked is sent directly to the processing plant. Only 10 percent of the fruit harvested in this area is directed to the packing house where it is graded, and the poorer quality fruit is redirected to the processor. In the southwestern region of the U.S. (California, Arizona and Texas) normally all fruit is sent first to a packing house, where the fruit is graded for the fresh-table market, and the remaining fruit is then sent to the processor. The only exception to this procedure occurs when, because of low temperatures in a given area, the fruit on the trees becomes frozen. In an effort to salvage as much of the fruit as possible, the frozen fruit is immediately picked and shipped directly to the processor as field run fruit.

Processing Steps

There are a number of similar or identical process steps in the manufacture of most citrus products. For example, the receiving, washing, intermediate storage, extraction and finishing process steps are common to all single strength juice plants. In addition, the juice concentrating process step must be added for the production of a frozen concentrate. In the manufacture of citrus segments the process steps which are common to all citrus segment plants are mechanical peeling, caustic treating, sectionizing, canning or bottling, and cooling. The peel and pulp (including rejected fruit) are processed into a dried citrus pulp and a molasses. These can be marketed as separate items or the molasses can be added back to the dried citrus pulp.

Receiving/Storage/Washing - When the fruit is received at the processing plant, it is transferred to intermediate storage prior to processing. This storage is usually sized to hold one to three days supply of fruit for the plant. When needed, the fruit is withdrawn from storage and washed before processing to remove any foreign materials including pesticides and insecticides that are adhering to the fruit. Either high pressure water sprays or immersion in water, in combination with brush scrubbers, is the conventional method of fruit cleaning. All free surface water must be drained from the fruit prior to extracting the juice.

Extraction - In this process step the raw citrus juice is extracted from the fruit by mechanical methods. In a reamer type extractor, the fruit is cut into halves and each half reamed separately to remove the juice. In another system the juice is extracted from the whole fruit through a hollow tube while pressure is applied to the exterior surface of the fruit. In another procedure, the fruit is sliced and the juice removed from the fruit halves by pressure on the exterior of the fruit. An average yield of juice is 480 l/kkg (115 G/T) of fruit processed.

Finishing - Mechanically extracted juice contains seeds, pips and segment membranes (rag) that must be removed. This separation is usually accomplished by a screw or paddle type finisher (pulp press) where the pressure applied and the size of the perforations (openings) control the degree of solids removal. The finished juice is blended and ready for canning or bottling as a single strength juice.

A fruit base drink can be manufactured by washing the citrus pulp solids discharged from the finisher with water and separating the solids in another finisher. The washed pulp is transferred to the peel process.

Juice Concentration - In concentrating citrus juice to 42° or 65° Brix, it is necessary to remove practically all of the pulp solids. If the finisher cannot be adjusted to remove a sufficient quantity of solids, then it is necessary to desludge the single strength juice in a centrifuge. The removal of solids reduces the viscosity of the juice during the concentration procedure. The citrus juice is concentrated in evaporators (rising or falling film) that have been designed for operation at a high vacuum and a short residence time. If citrus essence is to be recovered from the juice, this must be accomplished during the concentrating of the raw citrus juice.

Peeling - In this process step the peel is mechanically removed from the fruit. First the fruit is scalded with steam and cooled to loosen the peel. The fruit is manually placed or positioned into a receiving cup of the mechanical peeler, and is retained in the cups while the peel is scored and mechanically stripped from the fruit. The peel is transferred to the peel process part of the plant or sold to other processors.

Caustic Treatment - A caustic solution is applied to the whole peeled fruit by dipping or spraying. The caustic treatment removes any adhering rag or membrane prior to sectionizing. After treatment, but prior to sectionizing, all liquid caustic is thoroughly removed from the fruit by washing with water.

Segmenting - The segmenting process is either a manual or a mechanical operation. The manual or hand method produces a higher quality segment with less waste being generated than with the automatic sectioning machines. The sectioned fruit is inspected and packaged in cans or bottles.

Peel Shaving - A number of the citrus processors quarter and shave the peel to recover the citrus oil. This cold pressed oil is a valuable co-product if lemons or grapefruit are being processed. Mandarin and orange oils are of lesser commercial importance. To release the oil from the peel, the citrus halves are quartered and passed between knurled pressure rolls to break the oil sacs in the peel. A recirculated water stream is sprayed into the shaver to pick up the citrus oil being released from the shaved peel.

Citrus peel may also be shaved or deragged to produce a peel product acceptable for drying and ultimate use as a food ingredient (cake mixes, orange marmalade).

Products and Co-products

In a large citrus processing plant a number of the products or co-products will be made. Process descriptions of the more important products are outlined below.

Single Strength Juice - In this process, the raw juice is extracted from the fruit. The suspended solids (seeds, pulp, etc.) are then removed from the raw juice in a paddle or screw type finisher. The filtered juice from the finisher is blended and bottled for sale as a fresh chilled juice or pasteurized and canned as a single strength juice.

Concentrated Juice - In the production of concentrated citrus juice, the process is identical to that employed for single strength juice. However, in the finishing step (removal of pulp solids) a thorough removal of the solids from the juice is required. The clarified juice is then concentrated by evaporation to a 42° Brix as a frozen citrus concentrate or 65° Brix as a canned concentrate. A large percentage of the concentrated juice is put into 55-gallon drums. These drums are frozen and stored for later processing.

Cold Pressed Oil - In one method of citrus oil recovery, the oil is released from the peel by breaking the oil sacs on the peel surface, and collected by means of water sprays or rinse. The water/oil mixture is then separated by a centrifuge into three phases - cream (oil/water emulsion); water phase; and sludge. The citrus oil is recovered from the cream in a high-speed centrifuge. The water phase from the three-phase centrifuge is recycled as wash water to pick up additional oil being released from the peel. This water/oil mixture is returned to the three-phase centrifuge.

Segments - The citrus segments are packaged as two separate products: sections and salad which can be either canned or marketed as a fresh chilled product. The processes for making these two products are identical. The only difference is that the salad usually contains a higher percentage of broken segments and is considered a slightly lower quality product.

In processing sections or salad the fruit is washed, segmented (peeled, caustic treated and sliced) then canned or bottled as chilled fresh fruit.

Citrus Peel, Molasses and D'limonene - In recent years the major citrus processors have found it to be economically attractive to install waste heat evaporators in conjunction with their meal driers and molasses production. The process described here includes the waste heat evaporator. However, it should be recognized that the smaller citrus processor may deliver his peel to another processor or dry the peel without pressing as a whole citrus peel.

In the production of dried citrus peel and molasses, the peel and pulp residues are collected and ground in a hammermill. Lime is mixed into the ground mixture for pH adjustment, and the ground peel is fed into a pulp press to remove excess water. The pressed peel is conveyed to a direct fired hot air drier while the liquor from the press is screened to remove large solids which are recycled back to the press. The press liquor is concentrated to a molasses in the waste heat evaporator. The exhaust gases from the meal drier supply the heat for the concentration of the press liquor into a molasses product. D'limonene is recovered from the press liquor through the condensation of these exhaust gases as they are released from the meal drier.

Potatoes

General

The potato processing industry is normally classified according to the products manufactured.

1.	Potato Chips (snack food)	30 percent
2.	Frozen Potato Products	45 percent
3.	Dehydrated Potato Products	20 percent
4.	Canned, Hash, Stew and Soup Products	5 percent

Only these processes which are classified under items 2 and 3 above (frozen and dehydrated) will be considered in this report. Potato chip manufacture and canned potatoes will be considered as part of a later study.

In the manufacture of potato products, the most important consideration is the selection and procurement of a uniform high quality raw material. The processor would like the raw material received at his plant to have high solids content, low reducing sugars content, thin peels and uniform size and shape. High quality potatoes are particularly important when the plant operation is carried out over a long time period and the major portion of the potatoes used as raw material have been placed in storage for a period of several months. Most of the potato processing operations are shut down during much of the summer when the potatoes from the preceding harvest do not have desirable processing qualities or they are no longer in desirable supply.

The quality of the raw potatoes and type of manufacturing process are the outstanding factors determining the amount of waste generated in the manufacture of different potato products.

The current trend of industry is to produce a greater variety of products or styles, thus utilizing a greater amount of the undersize and undesirable potatoes which would otherwise be used for starch or flour production. The potato peelings, discarded pieces and residues from other processing wastes are usually fed to cattle. The low quality potatoes usually produce larger amounts of waste and represent a loss of yield to the processor. However, regardless of raw material quality, different manufacturing processes produce varying quantities of wastes and different waste constituents.

Processing Steps

Most potato processes have a number of steps which are common to the manufacture of potato products, i.e., storage, washing, peeling, slicing, and blanching, followed by a further processing step in which the final product character is determined.

Storage - To achieve maximum use and efficiency of his manufacturing facilities, the processor attempts to operate his plant on a year-round, continuous basis. Thus, it is necessary for large quantities of potatoes to be placed into storage at the end of each harvest for future use. The potatoes are often stored for many months prior to use. Today, below-ground storage systems - cellars - are gradually being abandoned in favor of above-ground construction. In either instance, it is necessary to maintain a high relative humidity to prevent dehydration of the stored potatoes. Shrinkage during long-term improper storage can result in a 90 percent water loss by evaporation and a 10 percent carbohydrate loss by respiration. However, proper temperature control and air recirculation will prevent these losses as well as prevent the occurrence of blackheart, mahogany browning, and stem rot.

Receiving/Washing - The potatoes that are received from the storage cellar or field are directed into a water flume or transport system by high pressure water hoses. In this manner the potatoes are withdrawn from the intermediate plant storage and transported to the processing area. The potatoes are withdrawn from the flume system by means of a metering wheel and fed into the process system. The transport water is normally pumped to a settling basin for silt removal and then returned to the receiving system.

Prior to processing, it is necessary to wash the potatoes. This is accomplished by passing the potatoes through a rotary drum or cylindrical washer where the potatoes are scrubbed either with brushes or merely by tumbling them together. In this washing operation the potatoes are also subjected to water sprays for the removal of foreign material and soil particles. Following the rotary washer the potatoes pass over a short drainage belt which permits internal recirculation of the wash water. An inspection of the potatoes is made on the drainage belt, and the undesirable whole potatoes are removed.

Peeling - There are a number of methods for the removal of peel from the potato. These methods usually involve a pretreatment with chemicals (lye) or heat (steam), which are followed by water sprays, abrasive rolls or rubber studded rolls to remove the peel from the potato. The peel loss, including trimming, can result in 15 to 30 percent loss of the potatoes processed. The combination of the above peeling methods has resulted in four systems which are known in the industry as abrasive peeling, steam peeling, lye (caustic) or wet lye peeling and dry caustic peeling. All these methods can be designed as either a continuous or a batch system. No simple peeling method provides the highest degree of peel removal for all potato products or raw potato types.

Abrasive peelers have rough coated rolls which rotate and remove the peel and small portions of the tissue by mechanically abrading it from the surface of the potato. Water sprays are used to remove the particles of peel from the abrasive rolls and the peeled potato. The potatoes are also rotated to insure removal of peel from all sides of the potato. Abrasive peeling is normally employed in the manufacture of potato chips. In this style of product it is not essential to have complete peel removal.

Steam peelers expose the potatoes to high pressure steam for short periods of time. After the steam treatment the potatoes are brushed and sprayed with water to remove the cooked peel particles. Steam peeling is an excellent procedure for producing a completely peeled product and is extremely effective on new or thin skinned potatoes.

Lye (caustic) peelers immerse or dip the potatoes in a hot lye solution. Longer immersion times are required at lower temperatures and the lye consumption increases with higher caustic concentrations. After removal from the hot lye solution, the potatoes are held for a short period of time to allow for the softening of the peel. The loose peel is then removed by brushes and water sprays in a manner similar to the removal of peel after steaming. If caustic treatment is used, the potatoes must be thoroughly washed to remove all traces of caustic along with the peel prior to further processing of the potato.

Dry caustic peelers are a recent modification of lye peelers. In this peeling process the potatoes are treated with a lye solution and after removal of the excess lye solution by draining, the potatoes are exposed to infrared heating. The caustic treated peel which has been loosened is removed by an abrasive scrubber utilizing one-half-inch-long rubber studs on rapidly rotating cylinders developed by the USDA Western Utilization Research Laboratory. The peel is removed in this abrasive scrubber with minimal rinsing. This method of peel removal has the beneficial effect of substantially reducing the volume and organic strength of the waste streams. In actual plant operation, the peelings are collected as a slurry having a 15 to 25 percent solids content.

A recent extension of this new development in peel removal has been to use the abrasive scrubber (USDA design) with other types of peel treatment. A similar reduction in waste loads has been realized when this scrubber has been employed with steam peelers or the conventional lye peelers. The reduction in water volumes and waste loads is equivalent to that attained when the scrubber is used in the dry caustic peeling system.

The trimming process should be considered as part of the peel removal. In this process the presence of eyes, blemishes, and remaining peel are often detected electronically, which directs the imperfect potato to the trim table where the imperfections are manually cut out of the potato. The degree of completeness of trimming is usually determined by the desired end product or style. All solid wastes from either trimming or peeling can be directed toward cattle feed.

Slicing/Dicing - In this process step, slicing or dicing, the potato is cut or subdivided into smaller pieces. The size and shape into which the potato is subdivided is dependent upon the end product. In any cutting process a number of potato cells are ruptured, releasing considerable amounts of starch. The more extensive the cutting, the greater the amount of starch that is released. This starch is washed from the surface of the potato pieces and usually appears in the transport or cutting water.

Many processors are now installing hydroclones to remove the starch in the form of a slurry from the wash water. This crude starch slurry is then shipped to a starch processor for further refining.

Blanching - After peeling and slicing the potato, the pieces are blanched to deactivate the enzymes, to remove surface air, to partially cook to form a grease barrier on the particle and if necessary to remove excessive sugars. Blanching also can be used to effect a degree of sterilization. Either steam or water is used for blanching potatoes. Steam is used when it is necessary to minimize leaching; water blanching is employed when it is necessary to remove constituents such as sugars from the potato pieces. It is common practice to arrange the blanchers for series flow of the potato pieces and parallel flow of the hot blanching water. For dehydrated potato products, the potato pieces are water-blanched, water-cooled, and then steam-blanched or cooked prior to mashing and mixing.

Product Styles

Following the blanching process, the potatoes can be further processed into products of two major categories: frozen and dehydrated.

Frozen Potato Products (French Fries, Hash Brown, etc.)-In the manufacture of frozen potato products, many processors add back ingredients after blanching and prior to frying and cooking. The frying is accomplished in a continuous belt unit at a temperature of 300° to 350°F. Following frying, the potato pieces are quick frozen in a tunnel freezer, then inspected, sorted and sized prior to packaging and warehousing. The only waste loads which are generated from this portion of the process are wastes from the fryer-scrubber, clean-up of the fryer and freezer belts, freezer thawing, cooling water, etc.

Dehydrated Potato Products (Granules, Flakes, Slices) - The potato slices or dices which are dehydrated as individual pieces are dried following blanching in an atmospheric recirculated air tunnel or conveyor drier. If granules or flakes are to be processed, then the blanched potato pieces are mashed and conditioned prior to drying as flakes on a drum drier (flaker) or as granules in a fluid bed drier.

SECTION IV

INDUSTRY CATEGORIZATION

CATEGORIZATION

In developing waste water effluent limitation guidelines and standards of performance for the Canned and Preserved Fruits and Vegetables Industry, a judgment must be made as to whether limitations and standards are appropriate for different segments (subcategories) within the industry. The first phase of the study is limited to processors of apple products (except caustic peeled and dehydrated products), citrus products (except pectin and pharmaceutical products) and frozen and dehydrated potato products. Other commodities will be studied in a subsequent study. In order to identify any such subcategories, the following factors were considered.

1. Raw material
2. Products and by-products
3. Production processes
4. Age of plant
5. Size of plant
6. Plant location
7. Waste treatability

After considering each of these factors, it was concluded that the segment of the Canned and Preserved Fruits and Vegetables industry included in this study consisted of three different raw materials: apples, citrus, and potatoes. The apple and potato processing industries were further subdivided into two subcategories each. The subcategorization selected for the purpose of developing waste water effluent limitations guidelines and standards are as follows:

1. Apple Processing: Apple Juice
2. Apple Processing: Apple products except juice
3. Citrus Processing: All products
4. Potato Processing: Frozen products
5. Potato Processing: Dehydrated products

The differences in raw waste characteristics for the five subcategories are given in Table 5. The rationale for this subcategorization is detailed throughout the remainder of this section.

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RATIONALE FOR CATEGORIZATION

Raw Material

Table 5 compares the waste water character and water usage for apple, citrus and potato processing. From the quality and amount of waste water generated it is obvious that apples are different from citrus, and both are different from potatoes. Their chemical composition and physical character also emphasize differences from apples to citrus to potatoes.

A number of different varieties of apples are used in the apple processing industry, and a single plant generally processes more than one variety. Some varieties are grown primarily for the table market, and in other areas apples are grown specifically for the processing plant; i.e. the Gravenstein in the Western, and the York Standard in the eastern part of the U.S. When those varieties, i.e. Delicious, Jonathan, etc., which are grown for the table market, are removed from storage, that fruit not meeting the table of fresh market standards is directed to the processing plant. It is these apples that are shipped from one region to another to extend the canning season in apple-short regions. For instance, Delicious apples from Washington are shipped to California to plants that usually process the locally grown Gravenstein variety.

Table 6 compares the waste character of 6 eastern apple plants with three west coast plants. The average BOD indicates that neither geographic location nor apple variety significantly affects waste loadings.

Citrus fruits include oranges, lemons, limes, grapefruits, and other varieties such as tangerines that are grouped under the heading exotics. Effluents from processing oranges, lemons, grapefruits, etc., are all essentially alike. Differences in fruit or size of fruit do not produce different waste loads.

Table 7 shows the effect of various ratios of grapefruit (lemons, limes, etc.) to oranges on the waste loading. The average BOD decreases, then, increases and decreases again as the ratio of grapefruit to oranges increases from zero to over 50 percent. Table 8 compares the BOD in kg/kkg (lb/ton) at one plant in 1970 with the ratio of grapefruit to oranges in its raw material mixture. There is no-trend or correlation between the variety of fruit and waste water quality or character.

Table 9 compares the waste character of 25 Florida citrus plants with two California plants. The average BOD indicates that neither citrus type nor geographic location significantly affect waste loadings.

A number of different varieties of potatoes are used in the potato processing industry. Some are particularly well suited to the production of a specific product, such as french fries, and are grown for that purpose. Although there may be variations in waste loads associated with the variety of potato being processed, these variations are not significant as shown in Table 10 which compares the waste loading for 9 western potato plants (Idaho, Washington and Oregon) with three eastern plants. The similarity between the BOD values indicates that neither potato variety nor geographic location significantly affect waste loading.

In summary it has been shown that differences exist among apples, citrus, and potatoes but that other differences such as variety of raw material and geographic location do not seriously affect waste water loadings. These similarities and differences, attributable to raw material, support the present subcategorization.

TABLE 5

DISTRIBUTION OF WASTE LOAD BY SUBCATEGORY

PRODUCT STYLE	Flow		BOD		Suspended Solids	
	l/kkg AVERAGE(RANGE)	gal/T AVERAGE(RANGE)	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)
APPLE PROCESSING						
Apple Juice	2880(1880-3540)	690(450-850)	2.05(1.6-2.55)	4.1(3.2-5.1)	0.3(0.15-0.40)	0.6(0.3-0.8)
Apple Products except juice	5360(1380-14800)	1290(330-3550)	6.4(3.4-10.1)	12.8(6.8-20.2)	0.8(0.35-1.05)	1.6 (0.7-2.1)
CITRUS PROCESSING						
All Products	10120(710-24940)	2425(170-5980)	3.2(0.45-8.5)	6.4(0.9-17.0)	1.3(0.02-7.95)	2.6(0.04-15.9)
POTATO PROCESSING						
Frozen Products	11300(4090-15510)	2710(975-3725)	22.9(4.45-36.95)	45.8(8.9-73.9)	19.4(5.1-45.5)	38.8(10.3-91.0)
Dehydrated Products	8761(6530-12010)	2100(1565-2880)	11.05(7.75-15.2)	22.1(15.5-30.4)	7.35(3.8-12.15)	14.7(7.6-24.3)

TABLE 6

EFFECT OF LOCATION FOR VARIOUS APPLE PLANTS
(OTHER THAN JUICE ONLY PLANTS)

		BOD	
LOCATION	NUMBER PLANTS	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)
East	6	5.75(1.4-8 .5)	11.5(2.8-17.0)
West	3	6.5 (3.4-10.1)	13.0(6.8-20.2)

		FLOW	
		l/kkg AVERAGE(RANGE)	gal/T AVERAGE(RANGE)
East	6	2290(1790-2790)	550(430- 670)
West	3	2640(1190-6050)	630(285-1450)

TABLE 7

EFFECT OF RAW MATERIAL AT VARIOUS CITRUS PLANTS

RATIO OF GRAPEFRUIT/ORANGES	NUMBER PLANTS	FLOW		BOD	
		1/kkg AVERAGE(RANGE)	gal/T AVERAGE(RANGE)	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)
0.50 -- 1.00	4	5675(1630-9090)	1360(395-2180)	3.1 (0.7-6.7)	6.2(1.4-13.4)
0.20 -- 0.49	6	8220(2085-16180)	1975(500-3880)	3.75(1.4-6.4)	7.5(2.8-12.8)
0.15 -- 0.19	2	14330(9590-19060)	3435(2300-4570)	1.95(1.6-2.3)	3.9(3.2- 4.6)
0.00 -- 0.14	3	7260(1360-8010)	1740(325-1920)	4.05(1.3-8.25)	8.1(2.6-16.5)

TABLE 8

EFFECT OF RAW MATERIAL MIX AT CITRUS PLANT 123 (MARCH, 1970)

GRAPEFRUIT/ORANGES	CAPACITY kkg/Day	CAPACITY Tons/Day	BOD kg/Day	BOD lb/Day	BOD kg/kkg	BOD lb/T
0	1870	2065	5830	12845	3.1	6.2
0	1480	1630	13250	29190	8.95	17.9
0	420	465	235	515	0.55	1.1
21	1890	2080	10340	22770	5.45	10.9
36	1970	2170	10310	22710	6.15	12.3
54	1430	1580	2450	5405	1.7	3.4
57	1620	1780	11480	25280	7.1	14.2
59	1170	1290	2100	4635	1.8	3.6
65	1220	1345	3680	8105	3.0	6.0

TABLE 9

EFFECT OF LOCATION FOR VARIOUS CITRUS PLANTS

LOCATION	NUMBER PLANTS	BOD kg/kkg AVERAGE(RANGE)	BOD lb/T AVERAGE(RANGE)
Florida	25	3.05(0.45-8.5)	6.1(0.9-17.0)
California	2	5.3 (2.35-8.25)	10.6(4.7-16.5)

TABLE 10

EFFECT OF LOCATION FOR VARIOUS POTATO PLANTS
(FROZEN POTATO PRODUCTS)

		FLOW		BOD5	
LOCATION	NUMBER PLANTS	l/kkg AVERAGE(RANGE)	gal/T AVERAGE(RANGE)	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)
West	9	12490(10350-15520)	2990(2480-3720)	25.25(12.3-36.95)	50.5(24.6-73.9)
East	3	10210(9640-10890)	2450(2310-2610)	21.9 (11.0-29.25)	43.8(22.0-58.5)

Products and By-Products

There is not a primary product that relates apples to citrus to potatoes. The primary product from apples is applesauce; the primary product from citrus is juice; and the primary product from potatoes is frozen french fries.

The differences in primary product styles emphasize the diversity of industry practices within the apple, citrus, and potato segment of the industry. Never-the-less, it is important to compare waste loads from various products and product mixes to determine whether plants can be grouped on a basis of similar raw waste characteristics.

The apple product styles considered included slices, sauce and juice or cider. The processing of slices or sauce is similar up to the final step of either canning, freezing or dehydrating. The difference in contributions of the final operation to waste water production and waste characteristics is small. Table 11 compares the waste characteristics for various apple product styles. Three apple juice plants have an average BOD of 2.05 kg/kkg (4.1 lb/T). The average BOD for five other apple products and product mixes were similar. The average BOD values ranged from a low of 2.05 kg/kkg (4.1 lb/T) to a high 6.85 kg/kkg (13.7 lb/T). While these BOD values are similar to each other, they are significantly different from the BOD from juice processing. The water usages are similar regardless of apple product or product mix although one flow value is high due to excessive water [illegible]ge at one of three plants in the group. Thus, similarity of flow and [illegible] allow all apple products except juice to be grouped in a single subcategory. The large BOD differences of these plants with juice plants requires separate categories.

The citrus product styles considered included juice and segments. Oil recovery and peel processing to cattle feed are considered co-products. Some plants usually produce only juice. The waste peel problem is met by shipping the peel to other processors for conversion to cattle feed or, in rare cases, the peel is disposed of as solid waste. Citrus segments are manufactured as a specialty product along with the normal production of citrus juice. The better quality fruit is used in the processing of segments while the poorer quality of fruit is directed to juice manufacture. The conversion of the citrus peel to cattle feed also solves an otherwise difficult disposal problem. The recovery of citrus oil is widely practiced in the industry. This oil is recovered from the surface of the peel as a cold-pressed oil. Highly contaminated waste streams are produced as part of the oil recovery process, and care must be taken to keep oil out of biological treatment systems. It is common practice in the larger plants to recover oil/water waste as a sludge and dispose of it through the waste heat evaporator. Although the citrus peel manufactured into cattle feed is considered a by-product, there is a strong economic incentive to produce this product.

Table 12 compares the BOD for various citrus products and product and co-product mixes. Seven different product styles have an average BOD from 3.15 to 3.5 kg/kkg (6.3 to 7.0 lb/T). The water usages are also similar for the various products considering the wide range in data. Thus, the similarity of raw waste characteristics among various citrus products and co-products confirm a single citrus processing category.

Within potato processing, two products were considered: frozen and dehydrated products. It was shown earlier that processing of frozen or dehydrated apples was similar up to the final operation and that only minor waste differences occur. There are, however, differences between dehydrated and frozen potato processing (See Sections III and V). Table 13 compares the BOD and flow for frozen potato products with dehydrated products. There are significant differences in BOD 11.05 and 22.9 kg/kkg (22.1 and 45.8 lb/T).

Three plants producing both frozen and dehydrated styles were also considered. At one plant complete 1972 data was available. The annual raw potato mix to frozen and dehydrated products was used to calculate the waste load using the average BOD for frozen and dehydrated products (Table 13). The calculated BOD value of 14.95 kg/kkg (29.9 lb/T) compared satisfactorily with its actual value of 13.8 kg/kkg (27.6 lb/T) (Table 13). Thus, the waste characteristics indicate two separate categories for potato processing.

Table 5 summarizes the raw waste load and water usage for each of the five product subcategories determined above. The citrus processing BOD is similar to the BOD from the two apple subcategories but different from the two potato subcategories. The citrus processing flow is similar to the water usage from the two potato subcategories but different from the two apple subcategories. This data confirms that five subcategories are needed for the purpose of developing effluent limitation guidelines and standards.

Production Processes

Industrial processing practices within the fruit and vegetable industry are diverse and produce different waste loads. However, final products relate directly to the processes employed and since final products have been previously used for subcategorization, the many differences and similarities in production processes support the five industry subcategories. There are a few processing differences that occur within these subcategories and these must be considered to determine their effect on raw waste loads and categorization.

In apples, two different peelers are used. The mechanical peelers are the most popular. The peeler can be adjusted to remove a greater or lesser percentage of the fruit imperfections and the resulting peel and core can be collected and used in the production of juice. Caustic peelers are also used by apple processors. The peel loss is not as great in caustic peeling when compared to mechanical peeling. The resulting peel waste, however, cannot be utilized in juice or cider manufacture. However, sufficient data is not available to evaluate the effect of caustic peelers on waste waters from the apple industry. Therefore, apple processors utilizing caustic peelers will be considered in a later study.

In the citrus industry there are variations in the extracting equipment used. Large plants may in fact use more than one style of machine in a given process step. Citrus waste loading data does not show differences attributable to the different machines. Another process variation within the citrus industry is the utilization of waste heat evaporators. Many large citrus plants use the exhaust gases from the meal dryer to supply heat for the concentration (recovery) of high strength wastes (such as press liquor) in the waste heat evaporator. Table 14 compares the average BOD from plants with waste heat evaporators to plants without the evaporator. The result is interesting in that the average BOD is a little higher when the waste heat evaporator is present. However, the similarity in the average and BOD range is sufficient to confirm the citrus categorization without regard to presence or absence of the waste heat evaporator.

Other than variations in production processes which are associated with product style, the only process step exhibiting significant variations in waste production in potato processing is that of peeling. Peeling methods may be placed in four groups; wet lye, dry lye, steam, and abrasion. Several historical publications have associated different waste loadings with different peeler types. However, recent equipment developments such as a low water usage scrubber used for separating softened peel have resulted in lower waste loads than older peeler installations using water sprays for peel removal.

Table 15 attempts to differentiate various peeling methods from total raw waste characteristics. Limited data indicates that BOD effluents from wet caustic systems can be reduced by a low water usage scrubber and that caustic systems followed by a USDA scrubber can reduce the BOD further. However, the BOD and water usage data in Table 15 cannot differentiate peeler methods. Therefore, further subcategorization by peeler method is not possible.

Thus, production processes are either associated with final product style or do not have an important impact on categorization. Accordingly, production processes support the five industry subcategories developed earlier.

Age of Plant

The age of a plant is somewhat difficult to define. Some processors give the date of the founding of the company, which may bear little relationship to the age of the processing equipment. The average age of the old plus the new process equipment is more meaningful, although the average of very old and very new equipment is less meaningful. The industry is competitive, so that older units that prove to be inefficient are usually replaced. No correlation was found between any measures of plant age and waste character or water usage.

Size of Plant

The size of an apple, citrus, and potato plant is important from a technical as well as an economical standpoint. A small plant may not have as many end-of-process treatment alternatives as a large plant, but may have more in-plant control alternatives than a large complex plant. The importance of size has been realized in the fruits and vegetables industry and size has been thoroughly considered in this categorization.

Table 16 compares waste character and water usage for apple plants with capacity less than 9.1 kkg per hour (10 T/hr.) and capacity greater than 9.1 kkg/hr. (10 T/hr). Only apple plants whose only product is juice are omitted. The BOD for the two plant sizes are very close 5.9 and 6.15 kg/kkg (11.8 and 12.3 lb/T). The ranges of BOD are also similar. There is a large difference in water usage but this difference is attributable to a single plant with high water flows. Thus, similarities in raw waste load suggest apple plant size does not have an impact on categorization.

Table 17 compares various citrus plant sizes with waste character (BOD) and water usage. The initial comparison is between plants with capacities greater or less than 320 kkg/day (350 T/day). The differences in BOD 3.2 and 3.3 kg/kkg (6.4 and 6.6 lb/T) and water usage 8,390 and 10,600 l/kkg (2010 and 2540 gal/T) are not considered significant especially in view of the large ranges of BOD and flow data. The second comparison is between plants with a capacity of 910 to 2000 kkg/day (1000 to 2200 T/day) and plants with a capacity less than 910 kkg/day (1000 T/day) or a capacity greater than 2000 kkg/day (2200 T/day). Again, the variability of the data is large and the similarity of average BOD and flow values suggest citrus plant size does not have an important impact on categorization.

Table 18 compares various potato plant sizes with waste character (BOD) and water usage. Frozen and dehydrated products are considered individually. Comparisons for frozen potato products include plants with capacity greater than and less than 360 kkg/day (400 T/day) and also 450 kkg/day (500 T/day). Neither the differences in BOD or water usage appears to be important. The variability of the data and the impact of a single plant is shown by the high average BOD (25.65 kg/kkg

(51.3 lb/T)) for plants with capacity less than 360 kkg/day (400 T/day) and low BOD 20.35 kg/kkg (40.7 lb/T) for plants with capacity less than 450 kkg/day (500 T/day). Comparisons for dehydrated potato products include plants with capacity greater than and less than 360 kkg/day (400 T/day) as well as 450 kkg/day (500 T/day). There are apparent differences in BOD and flow for small and large plants but the variability of BOD and flow data as well as the limited data base (seven plants) must be considered. Also, higher flows are observed at plants with lower BOD values and lower flows with plants with higher BOD so that treatment design differences which would influence capital costs are less important. In summary, no correlation exists between waste characterization and water usage data and size of dehydrated potato plants.

It is therefore concluded that size of plant is not a satisfactory basis for further industry subcategorization.

Plant Location

It is reasonable to expect that plant location could affect the selection of waste treatment alternatives for any plant in the fruits and vegetable industry. If the technical and economic feasability of achieving an effluent reduction is dependent on plant location, then additional subcategories must be established. In the earlier discussion of raw material, it was determined that geographical location did not affect the raw waste loading for either apples or citrus or potatoes (See Tables 6, 9 and 10). However, in this section availability of land, climate, and of high quality water is evaluated to determine their effect on effluent reduction for apple, citrus, or potato plants. Spray or flood irrigation is used throughout the apple, citrus, and potato subcategories. Irrigation requires relatively large amounts of land , but where inexpensive land of acceptable character is available, spray irrigation may be the least expensive solution to waste disposal problems. Biological systems such as activated sludge require much less land than spray irrigation, but the amount of land required could be difficult and expensive to acquire for a plant located in an urban area. In general, however, plants located in urban areas are served by municipal sewers. Land availability requirements will influence the choice of treatment technology to be used in a particular situation. However, sufficiently high levels of treatment are achievable with treatment processes which are not land-intensive. Thus, availability of land does not seriously affect the achievement of a high level of effluent reduction for apple, citrus, or potato plants.

TABLE 11

AVERAGE (RANGE) OF BOD AND FLOW FOR VARIOUS APPLE PRODUCT STYLES

		FLOW		BOD	
PRODUCT STYLE	NUMBER PLANTS	l/kkg AVERAGE(RANGE)	gal/T AVERAGE(RANGE)	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)
Juice Only	3	2880(1880-3540)	690(450- 850)	2.05(1.6- 2.55)	4.1(3.2- 5.1)
Sauce Only	3	3400(1380-6050)	815(330-1450)	5.35(3.4- 7.5)	10.7(6.8-15.0)
Sauce & Juice	3	1690(1190-14800)	405(285-3550)	6.85(5.8- 8.5)	13.7(11.6-17.0)
Apple Products (except Juice Only)	9	3920(1190-14800)	940(285-3550)	6.0 (1.4-10.1)	12.0(2.8-20.2)
All Apple Products	12	3660(1190-14800)	875(285-3550)	5.0 (1.4-10.1)	10.0(2.8-20.2)
Slices with Apple Products	3	6635(1790-14800)	1595(430-3550)	5.85(1.4-10.1)	11.7(2.8-20.2)

TABLE 12

AVERAGE(RANGE) OF BOD AND FLOW FOR VARIOUS CITRUS PRODUCT STYLES

		FLOW		BOD	
PRODUCT STYLE	NUMBER PLANTS	l/kkg AVERAGE(RANGE)	gal/T AVERAGE(RANGE)	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)
Segments Only	2	7455(4340-10570)	1790(1040-2535)	3.5 (2.65-4.35)	7.0(5.3- 8.7)
Citrus Products without Segments	19	10160(710-24950)	2440(170-5980)	3.15(0.45-8.5)	6.3(0.9-17.0)
Citrus Products with Segments	6	10850(4380-19180)	2600(1050-4600)	3.3 (1.4 -5.6)	6.6(2.8-11.2)
Citrus Products without Oil	5	7570(4340-10570)	1820(1040-2535)	3.35(1.45-5.6)	6.7(2.9-11.2)
Citrus Products with Oil	22	10690(710-24950)	2560(170-5980)	3.2 (0.45-8.5)	6.4(0.9-17.0)
Citrus Products without Feed	9	7570(1630-24950)	1820(390-5980)	3.15(0.7 -6.4)	6.3(1.4-12.8)
Citrus Products with Feed	18	11380(710-24740)	2730(170-5930)	3.25(0.45-8.5)	6.5(0.9-17.0)
All Products	27	10110(710-24950)	2425(170-5980)	3.2 (0.45-8.5)	6.4(0.9-17.0)

TABLE 13

AVERAGE (RANGE) OF BOD AND FLOW FOR VARIOUS POTATO PRODUCT STYLES

		FLOW		BOD	
PRODUCT STYLE	NUMBER PLANTS	l/kkg AVERAGE(RANGE)	gal/T AVERAGE(RANGE)	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)
Frozen Products	13	11320(4090-15510)	2710(980-3720)	22.9 (4.45-36.95)	45.8(8.9-73.9)
Dehydrated Products	7	8770(6530-12010)	2100(1565-2880)	11.05(7.75-15.2)	22.1(15.5-30.4)
Frozen & Dehydrated Products	3	9260(6380-12800)	2220(1530-3070)	13.8(13.65-13.95)	27.7(27.3-27.9)
All Potato Products	23	10270(4090-15510)	2460(980-3720)	18.1 (4.45-36.95)	36.2(8.9-73.9)

TABLE 14

EFFECT OF WASTE HEAT EVAPORATOR FOR VARIOUS CITRUS PLANTS

WASTE HEAT EVAPORATOR	NUMBER PLANTS	BOD kg/kkg AVERAGE(RANGE)	BOD lb/T AVERAGE(RANGE)
Present	10	3.25(0.45-8.5)	6.5(0.9-17.0)
Absent	17	3.2 (0.7-8.25)	6.4(1.4-16.5)
		FLOW l/kkg AVERAGE(RANGE)	FLOW gal/T AVERAGE(RANGE)
Present	10	10500(710-19970)	2520(170-4790)
Absent	17	9800(1360-24950)	2370(325-5980)

TABLE 15

AVERAGE (RANGE) OF BOD AND FLOW FOR VARIOUS POTATO PEELERS (FROZEN PRODUCTS ONLY)

		FLOW		BOD	
PEELER TYPE	NUMBER PLANTS	l/kkg AVERAGE(RANGE)	gal/T AVERAGE(RANGE)	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)
Wet Caustic	5	12120(10430-14560)	2900(2500-3490)	26.05(15.1 -36.95)	52.1(30.2-73.9)
Wet Caustic & USDA Scrubber	2	11890(10350-13430)	2850(2480-3220)	26.5 (20.75-32.25)	53.0(41.5-64.5)
Dry Caustic & USDA Scrubber	2	12810(10100-15520)	3070(2420-3720)	28.7((25.45-31.95)	57.4(50.9-63.9)

TABLE 16

AVERAGE (RANGE) OF BOD AND FLOW FOR VARIOUS APPLE PLANT SIZES
(OTHER THAN JUICE ONLY PLANTS)

		FLOW		BOD	
SIZE	NUMBER PLANTS	1/kkg AVERAGE(RANGE)	Gal/T AVERAGE(RANGE)	kg/kkg AVERAGE(RANGE)	lb/T AVERAGE(RANGE)
Less than 9.1 kkg/hr (10TPH)	4	6360(1795-14810*)	1520(430-3550*)	6.15(3.4-10.1)	12.3(6.8-20.2)
Over 9.1 kkg/hr (10TPH)	5	1960(1190-3340)	470(285-800)	5.9 (1.4- 8.5)	11.8(2.8-17.0)

*Single very high water usage responsible for difference

TABLE 17

AVERAGE (RANGE) OF BOD AND FLOW FOR VARIOUS CITRUS PLANT SIZES

PLANT SIZE	NUMBER PLANTS	FLOW l/kkg AVERAGE(RANGE)	FLOW gal/T AVERAGE(RANGE)	BOD kg/kkg AVERAGE(RANGE)	BOD lb/T AVERAGE(RANGE)
320 kkg/day (350 TPD) or less	6	8390(1360-24745)	2010(325-5930)	3.3 (0.7 -8.25)	6.6(1.4-16.5)
Over 320 kkg/day (350 TPD)	21	10600(710-24950)	2540(170-5980)	3.2 (0.45-8.5)	6.4(0.9-17.0)
Less than 910 kkg/day (1000 TPD)	7	8180(1360-24745)	1960(325-5930)	3.0 (0.7 -8.25)	6.0(1.4-16.5)
910 kkg/day-2000 kkg/day (1000 TPD-2200 TPD)	12	10520(2090-24950)	2520(500-5980)	3.8 (0.7 -8.5)	7.6(1.4-17.0)
Over 2000 kkg/day (2200 TPD)	9	11100(710-19070)	2660(170-4570)	2.65(0.45-6.55)	5.3(0.9-13.1)

TABLE 18

AVERAGE (RANGE) OF BOD AND FLOW FOR VARIOUS POTATO PLANT SIZES

PLANT SIZE	NUMBER PLANTS	FLOW l/kkg AVERAGE(RANGE)	FLOW gal/T AVERAGE(RANGE)	BOD kg/kkg AVERAGE(RANGE)	BOD lb/T AVERAGE(RANGE)
FROZEN POTATO PRODUCTS					
360 kkg/day (400 TPD) or less	4	11725(9640-14560)	2810(2310-3490)	25.65(11.0 -36.95)	51.3(22.0-73.9)
Over 360 kkg/day (400 TPD)	9	11140(4090-15520)	2670(980-3720)	21.65(4.45-35.8)	43.3(8.9-71.6)
450 kkg/day (500 TPD) or less	6	10600(4090-14560)	2540(980-3490)	20.35(4.45-36.95)	40.7(8.9-73.9)
Over 450 kkg/day (500 TPD)	7	11930(10100-15520)	2860(2420-3720)	25.05(12.3 -35.8)	50.1(24.6-71.6)
DEHYDRATED POTATO PRODUCTS					
360 kkg/day (400 TPD) or less	3	9350(7450-11810)	2240(1785-2830)	8.6 (7.75- 9.45)	17.2(15.5-18.9)
Over 360 kkg/day (400 TPD)	4	8350(6530-12020)	2000(1565-2880)	12.9 (10.4 -15.2)	25.8(20.8-30.4)
450 kkg/day (500 TPD) or less	4	10015(7450-12020)	2400(1785-2880)	10.25(7.75-15.2)	20.5(15.5-30.4)
Over 450 kkg/day	3	7090(6530- 7760)	1700(1565-1860)	12.1 (10.4 -15.2)	24.2(20.8-30.4)

Climate can affect the performance of apple, citrus or potato waste water treatment facilities. Biological processes are affected by temperature. Low temperatures tend to reduce the rate of reduction of BOD_5, and activity may essentially cease where the waste water reaches freezing temperatures. However, trickling filters and other biological devices have been successfully operated in freezing weather (Section VII), particularly in potato processing (PO-128).

Climate can also affect the rate of evaporation and the total amount of net evaporation from ponds. This may affect the size of ponds or drying fields required for a given loading, but will rarely preclude their use. Thus, climate does not seriously affect the achievement of a high level of effluent reduction for apple, citrus, or potato plants.

The availability of inexpensive high quality water is not a problem at the present time at most apple, citrus, or potato processing plants. Only one or two isolated cases can be found where plentiful water supplies are not available, although some processors are located in areas of expensive water. These processors are usually more careful about water conservation than processors with plentiful water supplies who have little incentive to conserve water. Nevertheless, these plants without plentiful supplies of water are not at a serious economic disadvantage because of water costs.

In the future, water conservation is expected to be much more important as a means of reducing the cost of solving waste effluent problems and saving a natural resource. Thus, it appears that the availability of water has no serious effects on the achievement of high effluent reductions in the apple, citrus, or potato industry. In summary, neither availability of land nor climate nor availability of water seriously affect the feasability of achieving a high level of effluent reduction. Accordingly, it is not necessary to further subcategorize the apple, citrus, or potato industry due to effects from plant location.

Waste Treatability

Liquid wastes generated in the processing of apples and potatoes contain principally biodegradable organic matter in soluble and suspended form. As detailed in Section VII, practicable treatment processes are available to reduce the BOD contained in these wastes to levels suitable for discharge. Also, described in Section VII are in-plant control systems which result in high levels of waste reduction. The availability of such treatment and control processes makes it unnecessary to subcategorize based on waste treatability.

The wastes generated by the citrus industry are essentially biodegradable, but pose special considerations in the design and operation of the treatment processes discussed in Section VII. Citrus oil, which occurs in the skin and elsewhere in the fruit is biologically digested only with difficulty. In the operation of standard waste-treatment processes (e.g., activated sludge), special care must be taken to maintain a low concentration of oil because of its adverse impact on microorganisms. Close control of plant operating conditions is required to avoid filamentous growth and the production of a sludge that is most difficult to dewater. Despite these difficulties, it has been demonstrated that such processes as activated sludge, trickling filter, aerated lagooning, alternating aerobic and anaerobic ponds and spray irrigation can be expected to treat wastes from apple, citrus or potato processing plants, and subcategorization on the basis of treatability is not necessary.

SECTION V

WATER USAGE AND WASTE CHARACTERIZATION

WASTE WATER CHARACTERIZATION

Water is extensively used in all phases of the food processing industry. For example, it is used as one of the following: (1) a cleaning agent to remove dirt and foreign material, (2) a heat transfer medium for heating and cooling, (3) a solvent for removal of undesirable ingredients from the product, (4) a carrier for the incorporation of additives into the product, and (5) a method of transporting and handling the product.

Many of the steps used in the process of canning and freezing fruits and vegetables are common to the industry as a whole, and the character of the waste waters are similar in that they contain biodegradable organic matter. Typically, the fruit or vegetable is received, washed and sorted to prepare it for subsequent processing. Commodities such as apples, citrus and potatoes are then usually peeled when the end product style is in a solid form (slices, cubes, or powder). If the final product is a juice or liquid product, the peel is not removed from either the citrus or the apples. Subsequent process steps following the peel removal in which water may be used are trimming, slicing, blanching, cooling, concentrating and can washing/cooling. Water transport may be used in one or more parts of the process, and cleanup is common to all processes.

Although the steps used in processing the various commodities display a general similarity, there are variations in the equipment used and in the amount and character of the waste waters produced.

This section presents data relating to cooling and process water usage and waste characterization for each of the industry subcategories established in Section IV. The available data from plants in each subcategory were evaluated to determine current practices in each commodity as well as each subcategory.

Toward the end of the section, unit process data is compiled in order to determine plant water usage and waste characterization representative of a synthesized plant with minimum water usage.

The parameters used to characterize the raw effluent were the flow, Biochemical Oxygen Demand (BOD), and suspended solids (SS). As discussed in Section VI, BOD_5 and SS are generally considered to be the best available measure of the waste load.

Apples

Water Use and Waste Characterization

Table 19 lists raw waste loadings for BOD and SS from 12 plants representing the apple processing industry. These twelve plants range in size from 3,700 to 43,100 kilograms/hour (4.1 to 47.5 tons per hour). The water usage of these plants varied from 1190 liters per thousand kilograms (285 gallons per ton) to 14,800 l/kkg (3550 G/T) with an average flow of 3,660 l/kkg (875 G/T). The plant using 14,800 l/kkg (3550 G/T) was far removed from the other with the next closest one using 6,050 l/kkg (1450 gallons per ton). The BOD ranged from 1.4 to 10.1 kilograms per thousand kilograms (2.8 to 20.2 lbs per ton) and again the high water user had the highest BOD. The average BOD for the 12 plants was 5.0 kg/kkg (10.0 lb/ton). Suspended solids ranged from 0.15 to 1.05 kg/kkg (0.3 to 2.1 lb/ton) with the average being 0.5 kg/kkg (1.0 lb/ton). Data from plants utilizing processes excluded from this study (caustic peelers) or plants processing products not included in this effort (dehydrated apples) are not represented in Table 19.

The average lbs of BOD per ton for various product styles was discussed in Section IV (See Table 11). The BOD average ranged from 2.05 kg/kkg (4.1 lb/ton) for juice to 6.85 kg/kkg (13.7 lb/ton) for the sauce and juice group. The BOD averages for all the groups compared favorably to the BOD of 5.0 kg/kkg (10.0 lb/ton) for all apple products with the exception of the plants producing juice. The flow averages ranged from 1690 to 6,635 l/kkg (405 to 1595 G/T) with the average for all apple products being 3,660 l/kkg (875 G/T).

TABLE 19

LIST OF APPLE INDUSTRY WASTE LOAD

(AP) CODE	PRODUCT STYLE	CAPACITY kg/hr	CAPACITY T/hr	FLOW l/kkg	FLOW gal/T	BOD kg/kkg	BOD lb/T	SS kg/kkg	SS lb/T
126	SA & SL	8.6	9.5	1790	430	6.05	12.1		-
134	SA	5.0	5.5	2790	670	3.4	6.8	0.95	1.9
136	JUICE	9.1	10.0	1880	450	1.6	3.2	0.35	0.7
140	SL	6.3	7.0	14800	3550	10.1	20.2	0.35	0.7
139	SA & SL & JUICE	31.0	34.2	3340	800			0.70	1.4
121	SA	15.9	17.5	1380	330	7.5	15.0	-	-
114	SA & JUICE	43.1	47.5	1190	285	8.5	17.0	-	-
103	SA & JUICE	21.4	23.6	2130	510	6.25	12.5	.3	0.6
107	SA & JUICE	15.9	17.5	1750	420	5.8	11.6	.35	0.7
141	JUICE	12.5	13.8	3210	770	2.0	4.0	.15	0.3
133	JUICE	4.5	5.0	3540	850	2.55	5.1	.40	0.8
128	SA	3.7	4.1	6050	1450	5.0	10.0	1.05	2.1
(All Product Styles)									
AVERAGE		14.8	16.3	3660	875	5.0	10.0	0.5	1.0
No. Samples		12	12	12	12	12	12	9	9
(APPLE JUICE)									
AVERAGE		8.7	9.6	2880	690	2.05	4.1	0.3	0.6
No. Samples		3	3	3	3	3	3	3	3
(APPLE Products Except Juice)									
AVERAGE		7.9	8.7	5360	1290	6.4	12.8	0.8	1.6
No. Samples		5	5	5	5	5	5	3	3

SA = Apple Sauce
SL = Apple Slice

Factors Affecting Waste Water

The condition of the raw fruit has an important bearing on the quality of the waste water. Fruit condition varies during the processing season because at the start of the season freshly picked fruit is processed, while at the end of the season, the fruit has been stored for several months. The waste water quality can be expected to vary from year to year as well, in response to yearly changes in fruit quality.

The type of peeling employed has a marked effect on waste water quality. In particular, caustic peeling produces a higher BOD and SS loading than mechanical peelers. Variations can also be expected among mechanical peelers. It should be noted, however, that higher waste water loadings do not necessarily imply higher fruit loss. Also the waste load generated by mechanical peeling falls to the floor, or is returned by the equipment and eventually appears in the cleanup water.

Water usage can, also, be expected to affect waste water quality. Data indicate that decreased water usage tends to concentrate the organic materials in the water. This effect is desirable since the reduction in effluent volume reduces the costs of disposal or treatment.

In Section IV the differences in plant size (See Table 16) and plant location (See Table 6) were determined to have no significant effect on waste water character. One of the most important factors affecting waste water quantity is the attitude of the management and workers. Where water has been cheap and waste disposal has not been considered to be an important problem, water usage can be excessive. As an example, plants AP-134 and AP-128 both produce sauce, but the water usage is 2,790 l/kkg (670 G/T) and 6,050 l/kkg (1,450 G/T) respectively. There are no readily explainable reasons for the difference.

Water transport adds to water usage, particularly where the water is not recycled. One type of mechanical peeler requires the apples to be fed to the peeler by water transport. The use of this type of peeler, therefore, requires more water than a manual feed peeler.

The majority of plants, especially the smaller ones, currently appear to be using once-through cooling water in the cooking and cooling step. They also do not segregate can-wash and can-cooling water. Water consumption can be reduced by recirculating cooling water.

It has been found that the use of high-pressure pumps for supplying the cleanup water reduces the amount of water required. Substantial savings in cleanup water can, also, be achieved by a practice of turning off hoses when not in use. A plant operator has offered the opinion that about one half of the clean-up water could be saved, but no quantitative data are available.

Plant age is defined in this report as the average age of the processing equipment. Process equipment, even in long established companies, tends to be relatively new or in new condition. Older equipment tends to be less efficient and, because the industry is competitive, inefficient equipment is usually replaced.

Citrus

Water Use And Waste Characterization

Waste waters from citrus processing plants contain organic carbon and matter in suspended and dissolved form. The quantity of fresh water intake to plants ranges between 710 and 24,950 liters per thousand kilograms (170 and 5,980 gallons per ton) of raw material. Fresh water use is highly contingent upon in-plant conservation practices and reuse techniques and averages approximately 10,110 l/kkg (2425 G/T) of citrus processed. The nature and amounts of these water reuses as influenced by in-plant controls and operational practices have a substantial effect on resulting waste water quantities and characteristics. Reduction in water use with resulting minimum waste water volumes promises fewer problems in waste handling and disposal, and greater economy of treatment.

About two-thirds of the total solids in citrus juices are sugars and the same may be said of the waste water. Because of this citrus wastes are highly putrescible. Citrus wastes contain pectic substances which interfere with settling of the suspended solids. Primary clarification of citrus waste water is not as effective as with most other wastes. Citrus waste water contains a small amount of the essential oil that occurs mostly in the fruit peel. This oil is bacteriostatic but usually does not interfere with treatment procedures unless it accumulates in an anaerobic sludge digester. Citrus wastes are deficient in nitrogen and phosphorus compounds; treatment by biological procedures may be accelerated by adding these nutrients. Citrus waste water usually is somewhat acid because of the citric acid it contains. However, alkaline materials used in cleaning the equipment and lye-bath water from sectionizing operations tend to make the waste water alkaline, and at times very strongly so.

The volume of citrus waste water fluctuates through the harvesting season which usually begins in October and ends in June. The production of frozen orange concentrate is a continuous operation, running twenty-four (24) hours per day until it becomes necessary to clean the equipment. On the other hand, the other processing operations are mostly a one or two shift operation daily, and may shutdown completely on weekends or holidays, depending on fruit supply and market demand. The volume of waste water changes markedly when the production run is over and clean-up operations begin.

The strength of citrus waste water, also, shows considerable variation depending upon the processing operations that are running at the time. Cleaning of equipment at the end of the production run will alter the strength of the waste water significantly. The strength may be increased at the beginning of clean-up, then lowered as the cleaning progresses. The pH may change from mildly acid to strongly alkaline during this time. This is especially true when evaporators are "boiled-out" or the lye baths of the sectionizing operations are discharged.

The changes in strength, volume, and pH are such that biological treatment of the waste is rendered difficult unless fluctuations are leveled out. This is accomplished by a surge tank with suitable mixing facilities placed ahead of the treatment plant or with treatment plant design to handle these fluctuations.

Table 20 lists actual raw waste loadings for BOD and SS from 27 plants representing the citrus processing industry. These plants range in size from 27 to 5,710 kkg/day (32 to 6300 tons/day). The products include juice or segments only; juice or segments and oil; juice, oil, and feed; juice, segments, and feed; juice and segments; and juice, segments, oil and feed. The water usage ranges from 710 to 24,950 l/kkg (170 to 5980 G/T). The BOD range from a low of 0.45 to 8.5 kg/kkg (0.9 to 17.0 lb/ton) with an overall average of 3.2 kg/kkg (6.4 lb/ton). The suspended solids ranged from 0.02 to 7.95 kg/kkg (0.04 to 15.9 lb/ton) with an average of 1.3 kg/kkg (2.6 lb/ton). Plants with both land treatment systems and secondary treatment systems were used.

In Section IV (See Table 12), BOD and flow were discussed for various product styles. The BOD ranged from 0.45 to 8.5 kg/kkg (0.9 to 17.0 lbs per ton) for citrus products without segments, citrus products with oil, and citrus products with feed respectively; their respective BOD averages were 3.15, 3.2 and 3.25 kg/kkg (6.3, 6.4 and 6.5 lb/T). Segments had a BOD of 3.5 kg/kkg (7.0 lb/ton) which was the highest average of the group, but only 2 plants were represented. The BOD averages of the different groups varied from 3.15 to 3.5 kg/kkg (6.3 to 7.0 lb/ton) which compares very well with the 3.2 kg/kkg (6.4 lb/ton) for the 27 plants products all types of products. The water usage ranged from 710 to 24,950 l/kkg (170 to 5980 G/T) with the averages ranging from 7455 to 11,380 l/kkg (1790 to 2730 G/T), which compares to the 10,110 l/kkg (2425 G/T) for the average of the total 27 plants.

TABLE 20

LIST OF CITRUS INDUSTRY WASTE LOAD

(CI) CODE	PRODUCT STYLE	CAPACITY		FLOW		BOD		SS	
		kkg/day	T/day	l/kkg	gal/T	kg/kkg	lb/T	kg/kkg	lb/T
137	J & O	125	140	1630	390	2.35	4.7	0.02	0.04
139	J & O & F	1000	1100	9090	2180	6.7	13.4	2.7	5.4
101	J & O & F	190	210	1360	325	8.25	16.5	1.05	2.1
103	J & O & F	320	350	7550	1810	0.7	1.4	0.17	0.34
104	J & S	1130	1250	9590	2300	5.6	11.2	1.55	3.1
105	J & O & F	2270	2500	10010	2400	2.6	5.2	--	-
106	J & O & F	2090	2300	9590	2300	2.3	4.6	1.55	3.1
107	J & O	1090	1200	4380	1050	0.7	1.4	0.36	0.72
108	J & S & O & F	3410	3760	16180	3880	5.0	10.0	1.31	2.62
109	J & O & F	2860	3150	12430	2980	2.65	5.3	--	-
110	J & O & F	2860	3150	8010	1920	1.3	2.6	0.25	0.50
111	J & O & F	1840	2025	19970	4790	8.5	17.0	7.95	15.9
114	J & O & F	2450	2700	17010	4080	6.55	13.1	1.2	2.4
115	J & O & F	1840	2025	7260	1740	0.95	1.9	--	-
116	J & S & F & O	1225	1350	8630	2070	3.15	6.3	--	-
118	J & S & F	770	850	7130	1710	1.45	2.9	0.65	1.3
119	J & O & F	5710	6300	19060	4570	1.6	3.2	--	-
122	J & O	1020	1125	2085	500	6.4	12.8	1.25	2.5
123	J & O & F	3810	4200	6960	1670	1.6	3.2	0.9	1.8
125	S	27	32	10570	2535	4.35	8.7	--	-
126	J & O & F	5080	5600	710	170	0.45	0.9	0.02	0.04
127	S	225	250	4340	1040	2.65	5.3	0.40	0.79
128	J & O & F	285	315	24730	5930	1.35	2.7	--	-
129	J & S & O & F	1730	1910	19180	4600	3.2	6.4	--	-
130	J & S & O	1140	1260	4380	1050	1.4	2.8	1.15	2.3
133	J & O	1020	1125	24940	5980	2.3	4.6	--	-
143	J	980	1080	6210	1490	2.75	5.5	--	-
AVERAGE		1720	1900	10,120	2425	3.2	6.4	1.3	2.6
No. of Samples		27	27	27	27	27	27	17	17

J = Juice
S = Segment
O = Oil
F = Peel Products
P = Pectin

Factors Affecting Waste Water

Table 7 which is discussed in Section IV gives the ratio of grapefruit to oranges and the resulting raw waste loadings and water usage. Also, discussed in Section IV is Table 8 that shows the raw product mix at a single plant for one month. As these tables illustrate there is no correlation in waste loads when different ratios of grapefruit to oranges are processed. Plant location (See Table 9) was also determined to be an insignificant variable. The climate is very similar in the principal growing areas. Although citrus may be held in storage for brief periods in California, the fruit is usually processed as received from the field in Florida. Approximately 90 percent of the citrus grown in California goes to the fresh market. No significant change in waste loads could be tied to these differences.

The type of juice extractor used has a pronounced effect on waste water quality. If the extractor liberates the oil at the time of juice extraction, and the oil is not collected, but allowed to become part of the waste effluent, a much more degraded effluent will result.

The quantity of waste water from the oil/peel products process is small but contains a high concentration of contaminants. This material can be satisfactorily disposed of by spray irrigation when mixed with other effluent steams but is difficult to treat in activated sludge or similar biological systems. This material can, also, be added directly to the peel before it is dried or sent to the molasses evaporators. As shown in Table 14, availability of a waste heat evaporator does not significantly affect the raw waste loading.

Plant age is defined in this report as the average age of the processing equipment. Processing equipment, even in long established companies, tends to be relatively new or in new condition. Older equipment tends to be less efficient, and because the industry is competitive, inefficient equipment is usually replaced. In all plants visited, the processing equipment was determined to be relatively new on the basis of visual inspection. As a result of this, no difference can be attributed to effluent quantity or quality due to plant "age."

Perhaps the most important factor affecting waste water quantity is the attitude of the management and workers. Where water has been cheap and waste disposal has not been considered to be an important problem, water usage can be excessive. Water transport also adds to water usage. In many cases this water can be recycled. Barometric condensing and cooling waters, which are relatively clean, can be recycled if a cooling tower or large pond were included in the circuit. This could reduce water usage by 30 to 70 percent depending on the plant.

Neither waste water quality or quanity are influenced by plant size. Small plants (less than 910 kkg (1,000 tons) of raw material processed per day) produced essentially the same quality and quantity of waste water as large plants. (See Table 17).

Potatoes

Water Use and Water Characterization

Table 21 gives the raw loadings for BOD and SS from 23 plants representing the frozen and dehydrated potato processing industry. These 23 plants range in size from 180 to 1630 kkg (200 to 1800 tons) per day. The BOD ranged from 4.45 to 36.95 kg/kkg (8.9 to 73.9 lb/ton) with an average of 18.1 kg/kkg (36.2 lb/ton). Suspended solids ranged from 3.8 to 45.5 kg/kkg (7.6 to 91.0 lb/ton) with an average of 15.9 kg/kkg (31.8 lb/ton). Water usage ranged from 4090 to 15,510 l/kkg (980 to 3720 G/T) with an average of 10,270 l/kkg (2460 G/T).

Table 13 lists the BOD and flows for various potato product styles. Frozen products with data from 13 plants had an average BOD of 22.9 kg/kkg (45.8 lb/ton) with a range of 4.45 to 36.95 kg/kkg (8.9 to 73.9 lb/ton) and an average flow of 11,320 l/kkg (2710 G/T). Dehydrated products with data from 7 plants had an average BOD of 11.05 kg/kkg (22.1 lb/ton) with a range of 7.75 to 15.2 kg/kkg (15.5 to 30.4 lb/ton). The average flow was 8770 l/kkg (2100 G/T). Three plants producing both frozen and dehydrated products had a average BOD of 13.8 kg/kkg (27.7 lb/ton) and an average flow of 9260 l/kkg (2220 G/T).

Factors Affecting Waste Water

The quality of the waste water is affected by the condition of the raw product. Sometimes early in the processing season, the waste loading will go up due to freezing in the fields. Potatoes shrink or lose weight during storage. This weight loss is composed of water loss from the tubers, carbon dioxide loss and decay losses as a result of rotting. The amount of these losses are determined by storage conditions, such as: (1) temperature, humidity, evaporating power of the air, composition and movement of the air; and (2) maturity and condition of the potatoes at the time of storage. Usually the longer the potatoes are stored,the higher will be the waste loading and many plants show a marked increase in waste loading toward the end of the processing season.

In Section IV, the differences in size and location of potato processing plants (See Tables 10 and 18) were determined to have no significant effect on waste water character. One of the important factors affecting waste water quantity is the attitude of the management and workers.

Where water has been cheap and waste disposal has not been considered to be an important problem, water usage can be excessive.

Effluent Analyses By Unit Process

The following raw waste characteristics have been tabulated from the best available in-plant unit process waste characteristics. Total raw waste effluent values can be calculated, but caution must accompany such a tabulation. The tabulations should not be used to develop effluent limitation guidelines. The waste characteristics of primary concern are BOD_5 (five-day biochemical oxygen demand) and SS (suspended solids). The following tabulations summarize BOD_5, SS and water usage values by process steps for apples, citrus, and potatoes. They have been synthesized from available data acquired through in-plant sampling with some supplemental in-plant data acquired from processors. In only a few cases was complete in-plant data available. Information from 10 apple plants, 20 citrus plants, and 15 potato plants was used to develop these tabulations. The tabulations are not used to develop effluent guidelines. The purpose of this presentation is to show where substantial water savings can be realized and where substantital waste reductions can be accomplished. They should not be used to develop effluent limitations.

Washing, as listed in Table 22, includes receiving and sorting as well as fruit cleaning. The apples are dumped into a water filled tank and are washed with water sprays after leaving the tank or the associated water transport system. Mechanical peeling, slicing and deaeration are treated as separate process steps. Cooking and cooling waters can be kept separate and are shown as individual values. Cleanup (floor and equipment) normally occurs in a separate work shift, following one or two processing shifts.

Although it is not yet general practice in the industry, some plants recycle the water used for can cooling through a cooling tower or spray pond. When recycling, the small amount of spray water used to clean the cans following cooking is kept separate from the cooling water in order to keep organic material out of the cooling water. In this and subsequent tabulations, the can wash water is included in the water used for cooking. We estimate that the cooling water requirements can be reduced to about 5 percent of the once- through requirement of 1,182 l/kkg (283 G/T) or to a level of 58 l/kkg (14 G/T) as used in Table 22. The latter figure is used for the cooling step in apple processing. Seven of ten plants contributing data listed in Table 22 are primarily sampled plants processing stored fruit near the end of the canning season. The ten plants make different apple products and product mixes and range in size from less than 3.6 kkg/hr (4 T/hr) to more than 28 kkg/hr (31 T/hr). As shown on the accompanying water flow diagrams Figures 4-6, the production of each product style (sauce, slices and juice) employs a different set of operations. Water usage and characterization can be determined for the production of slices, sauce and juice. Water usage for the three product styles (sauce, slices and juice) are presented in Figures 4-6. The process steps employed in the manufacture of sauce are washing, peeling, slicing, cooking, cooling, transport and cleanup. The process steps for slices are washing, peeling, slicing, deaerating, cooking, cooling, transport and cleanup. The production of juice involves only washing (including receiving and sorting), transport, cooling and cleanup. Data from about 20 citrus plants processing different citrus products and co-products contributed to the tabulation given in Table 23. Fruit cleaning, as used in Table 23, includes washing, as well as receiving and sorting. The citrus is sometimes stored in bins and upon leaving the bins is washed with water sprays and/or roller brushes with sprays and sometimes detergent. Juice extraction may be accomplished by slicing the citrus in half and reaming each half simultaneously. After extraction, the peel and the majority of the pulp are separated from the juice and may, or may not, be processed for citrus oil and other by-products. Depending on the extractor, oil may or may not be liberated from the peel at this point. The juice is next passed through a finisher and may then be either processed into single strength (S.S.), which involves juice pasteurization/homogenization and can cooling, or concentrated which involves evaporation of the juice. The majority of the cleanup normally occurs in a separate work shift, following one, two, or two and one-half processing shifts.

Oil/peel-pulp by-products are manufactured from plants that have some type of juice operation. Additional water flows involved include the waste heat evaporator condensate, the waste heat evaporator's barometric condensate, the waste heat evaporator's scrubber effluent, and the oil lean residue from the d-limonene residue separator.

The production of segments involves waste water from peeling, caustic treating, washing, cooking, cooling and cleanup.

By referring to Figure 7, it is possible to develop water usage figures for plants making various product combinations. Water use figures for juice and oil processing, segment processing and juice, oil and peel product processing can be determined. The figures are the summation of the water flows from each of the process stops required to produce juice, oil, segments and peel products with minimum water usage.

There is a degree of variability for water usage and waste characterization among the products and product combinations. The majority of this variability is attributable to differences in plant operation and plant management and difference in availability of raw material, water, and waste treatment facilities. Minor differences in size, age and location of plants also contribute to the total variability. Even without consideration of these sources of variability, there is sufficient similarity for water usage and waste character among the product combinations to support a single category for the citrus industry.

Fifteen potato plants processing frozen and/or dehydrated potato products contributed to the waste characterization given in Table 24. In each of these potato processing subcategories, there are several processing steps using large quantities of water which are common to both categories.

For example, it is common practice to use water hoses to remove the potatoes from storage and direct them into a water transport system for delivery to the process area. In an exemplary water usage plant, the water which is used to receive and clean the potatoes is usually segregated from the process water. The receiving/cleaning water is recycled through a settling basin where there is sufficient retention time to allow the solids to settle out in the basin. The make up water to this closed system is added by water sprays which are positioned to rinse the potatoes as they enter the process.

Three methods of peeling are in current industrial use within the frozen and dehydrated potato processing industry: dry caustic, conventional wet caustic and steam. With the conventional wet caustic and steam peeling systems, large quantities of water were used for removal of the treated peel. This results in large waste loads appearing in the plant waste effluent discharge as can be seen in Table 24.

During the slicing step, large quantities of water are used to remove any starch adhering to the surface of the pieces. This water is also used to convey the pieces to the blanching step.

Water blanching is required for both frozen and dehydrated products since a large amount of the leachables must be removed from the potato pieces during the blanching step. In the case of frozen products, a three step series blanching system is used. While for dehydrated products the water blanching step is followed by a water cooling step and then a cooking step.

The frozen products are usually french fried while the majority of the dehydrated products are dried in a flake or granule form.

As shown on the accompanying water flow diagrams (Figures 8-9), the production of dehydrated and frozen products employs different process steps. Water usage and waste characterization can be determined for the production of both products. As mentioned earlier, the tabulations should not be used to develop waste water effluent limitation guidelines. The tabulations are presented only to show where substantial water savings can be realized and where substantial waste reductions can be accomplished.

TABLE 21

LIST OF POTATO INDUSTRY WASTE LOADINGS

(PC)		CAPACITY		FLOW		BOD		SS	
CODE	PRODUCT STYLE	kkg/day	T/day	l/kkg	gal/T	kg/kkg	lb/T	kg/kkg	lb/T
131	F	360	400	11800	2830	25.4	50.8	6.55	13.1
132	F & D	430	475	8590	2060	13.9	27.8	11.75	23.5
110	F	320	350	14560	3490	36.95	73.9	--	--
116	F	450	500	12510	3000	15.1	30.2	8.9	17.8
125	F	340	375	10880	2610	29.25	58.5	22.1	44.2
130	F	540	600	10430	2500	35.8	71.6	27.8	55.6
101	F & D			12800	3070	13.95	27.9	11.2	22.4
102	F	1630	1800	15510	3720	31.95	63.9	45.5	91.0
103	F	540	600	10090	2420	25.45	50.9	12.6	25.2
108	F	630	700	10340	2480	32.25	64.5	29.3	58.6
109	F	1040	1150	13430	3220	20.75	41.5	23.85	47.7
111	F	725	800	11260	2700	16.9	33.8	--	--
112	F	910	1000	12510	3000	12.3	24.6	--	--
115	D	220	240	8760	2100	8.6	17.2	--	--
136	D	590	650	7760	1860	10.4	20.8	12.15	24.3
107	D	540	600	7010	1680	10.75	21.5	9.8	19.6
113	D	500	550	6530	1565	15.2	30.4	--	--
122	D	340	375	11800	2830	9.45	18.9	--	--
127	F	450	500	4090	980	4.45	8.9	5.1	10.3
128	F & D	135	150	6380	1530	13.75	27.5	11.8	23.6
123	D	230	250	7460	1790	7.75	15.5	3.8	7.6
129	F	180	200	9630	2310	11.0	22.0	12.5	25.0
114	D	450	500	12010	2880	15.2	30.4	--	--
(All Product Styles)									
AVERAGE		550	610	10270	2460	18.1	36.2	15.9	31.8
No. Samples		23	23	23	23	23	23	16	16
(FROZEN PRODUCTS)									
AVERAGE		625	690	11300	2710	22.9	45.8	19.4	38.8
No. Samples		13	13	13	13	13	13	10	10
(DEHYDRATED PRODUCTS)									
AVERAGE		410	450	8760	2100	11.05	22.1	8.6	17.2
No. Samples		7	7	7	7	7	7	3	3

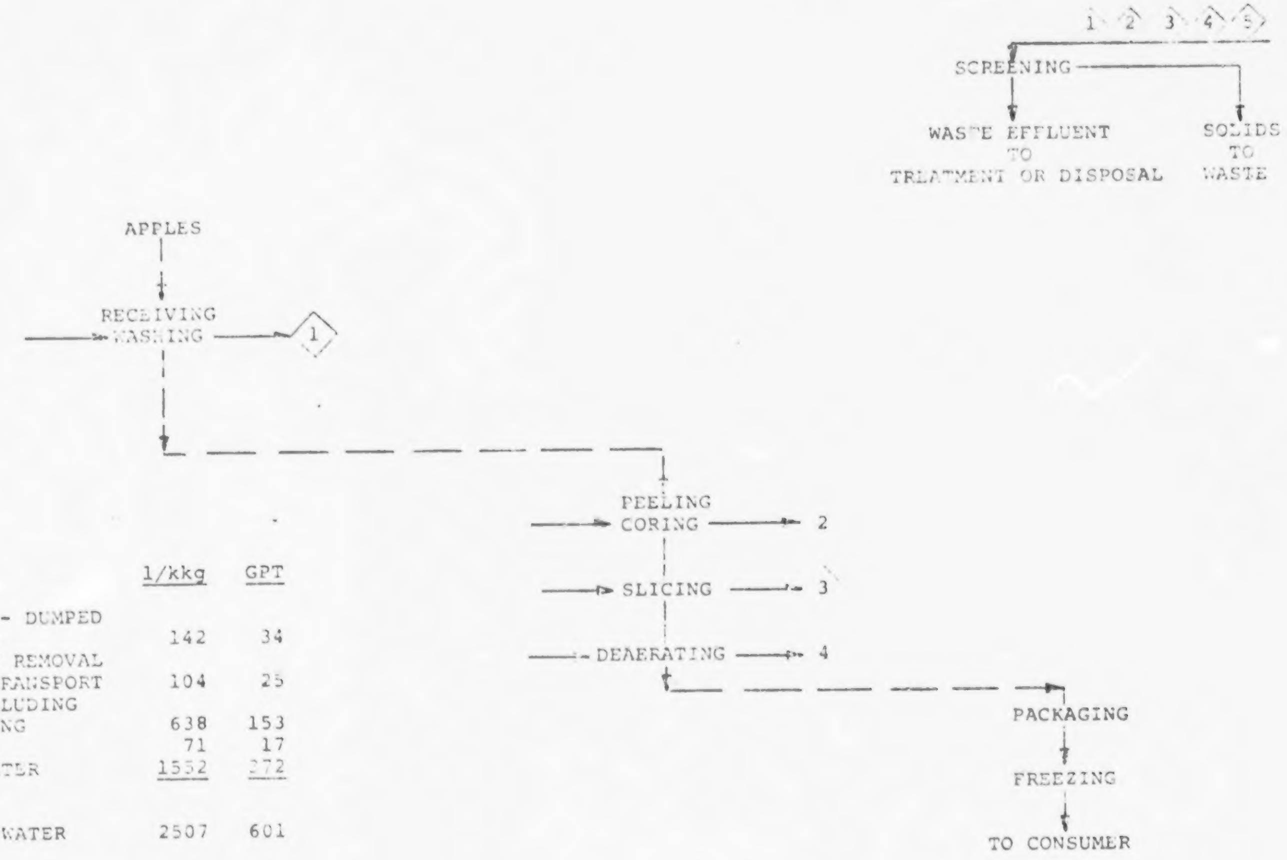
F = FROZEN PRODUCTS
D = DEHYDRATED PRODUCTS

TABLE 22

APPLES
Water Usage and Waste Characterization in Apple Processing

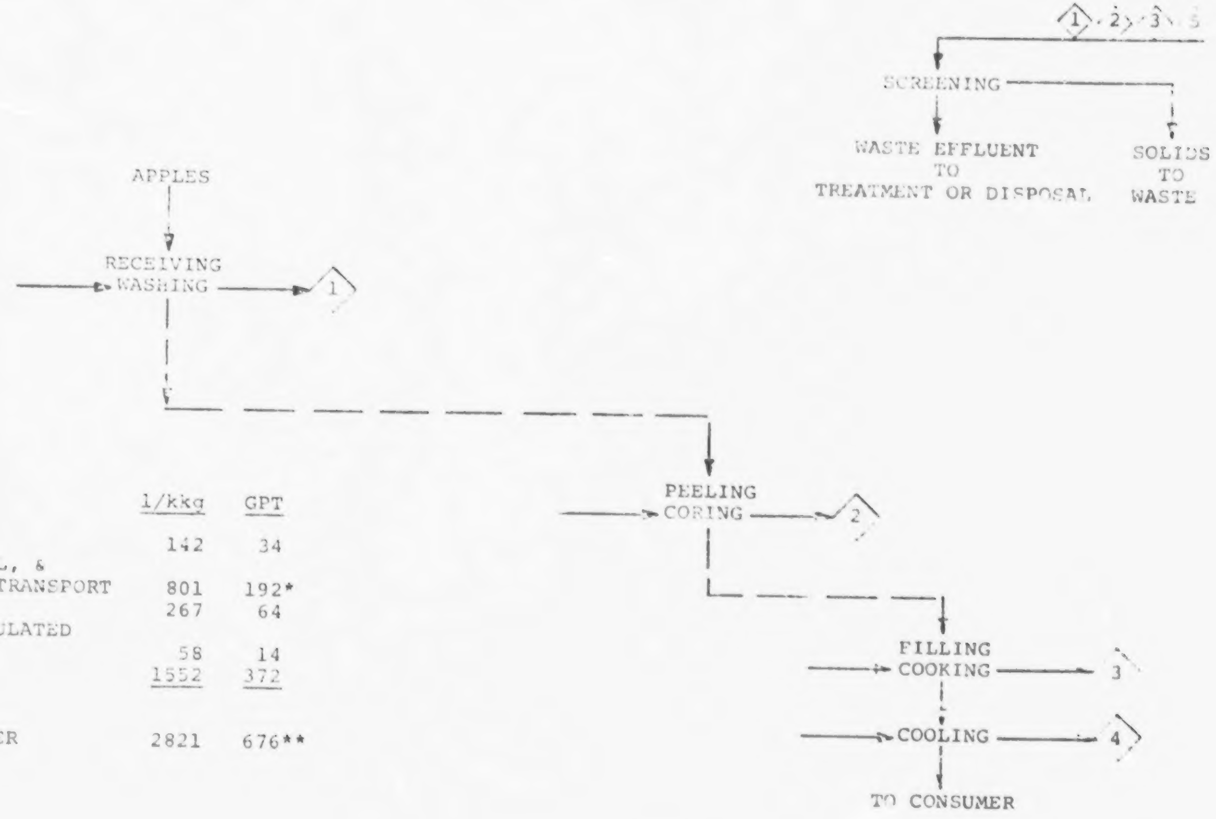
Process Step	Water Usage		BOD5		Suspended Solids	
	l/kkg	G/T	kg/kkg	lb/T	kg/kkg	lb/T
Washing	142	34	0.09	0.18	0.03	.06
Peeling						
Mechanical	104	25	0.16	0.31	0.015	0.03
Slicing	638	158	2.49	4.97	0.182	0.36
Deaeration	71	17	2.21	4.42	0.12	0.24
Cooking	267	64	0.14	0.27	0.05	0.10
Cooling (1)	58	14	0.02	0.03	0.005	0.01
Transport	58	14	0.02	0.03	0.005	0.01
Clean-up	1,558	372	1.90	3.80	0.30	0.60

(1) 95% recirculated


1 2 3 4 5
SCREENING
WASTE EFFLUENT TO TREATMENT OR DISPOSAL
SOLIDS TO WASTE
APPLES
RECEIVING WASHING
1
PEELING CORING
2
SLICING
3
DEAERATING
4
PACKAGING
FREEZING
TO CONSUMER

	1/kkg	GPT
⟨1⟩ WASH WATER - DUMPED EVERY 9 HRS	142	34
⟨2⟩ PEEL & CORE REMOVAL INCLUDING TRANSPORT	104	25
⟨3⟩ SLICING INCLUDING SLICE WASHING	638	153
⟨4⟩ DEAERATING	71	17
⟨5⟩ CLEAN-UP WATER	1552	272
TOTAL WATER	2507	601

FIGURE 4 WATER FLOW DIAGRAM - APPLE SLICES (FROZEN)

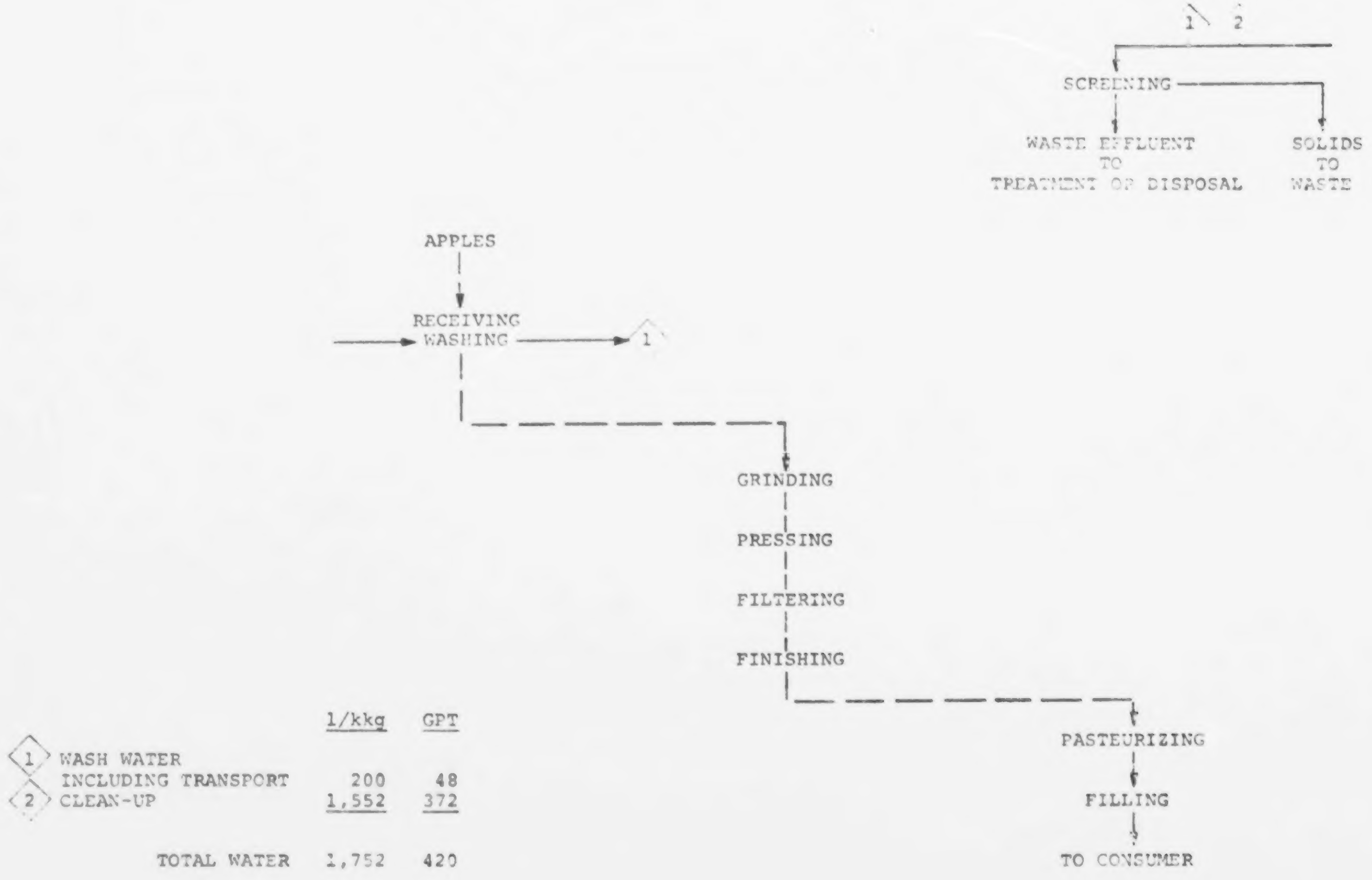

1 · 2 · 3 · 5
SCREENING
WASTE EFFLUENT TO TREATMENT OR DISPOSAL
SOLIDS TO WASTE
APPLES
RECEIVING WASHING
1
PEELING CORING
2
FILLING COOKING
3
COOLING
4
TO CONSUMER

		1/kkg	GPT
1	WASH WATER	142	34
2	PEEL & CORE REMOVAL, & SLICING INCLUDING TRANSPORT	801	192*
3	COOKING	267	64
4	CAN COOLING RECIRCULATED TO COOLING TOWER	58	14
5	CLEAN-UP WATER	1552	372
	TOTAL WATER	2821	676**

* Caustic Peeling 1127 l/kkg (270 Gal/Ton)

** 1, 2, 3, 5

FIGURE 5 WATER FLOW DIAGRAM - APPLE SAUCE


1
2
SCREENING
WASTE EFFLUENT TO TREATMENT OR DISPOSAL
SOLIDS TO WASTE
APPLES
RECEIVING WASHING
1
GRINDING
PRESSING
FILTERING
FINISHING
PASTEURIZING
FILLING
TO CONSUMER

	1/kkg	GPT
1 WASH WATER INCLUDING TRANSPORT	200	48
2 CLEAN-UP	1,552	372
TOTAL WATER	1,752	420

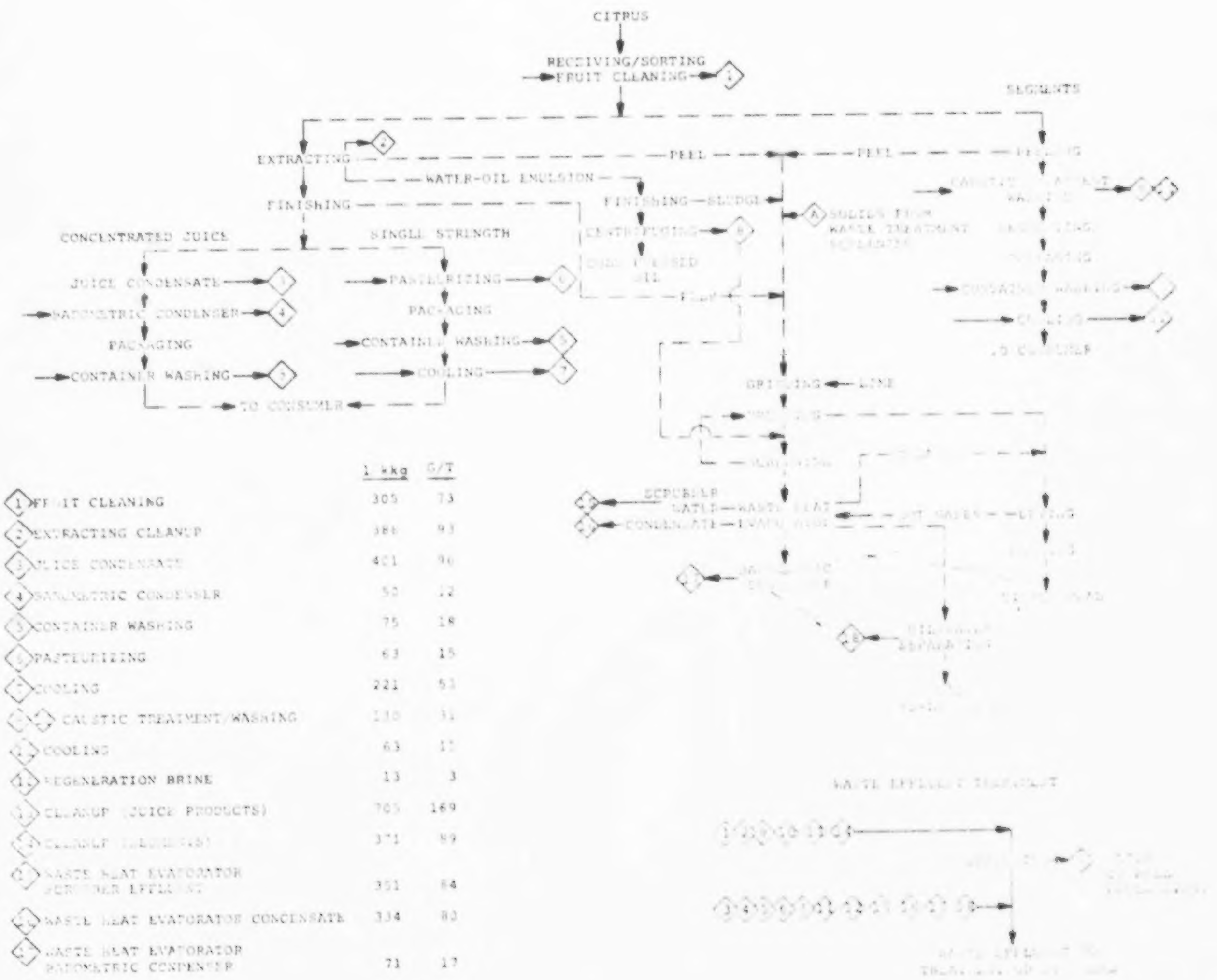
FIGURE 6 WATER FLOW DIAGRAM - APPLE Juice

TABLE 23

CITRUS
Water Usage and Waste Characterization In Citrus Processing

Process Steps	Water Usage l/kkg	Water Usage (G/T)	BOD5 kg/kkg	BOD5 (lb/T)	Suspended Solids kg/kkg	Suspended Solids (lb/T)
Fruit Cleaning	303	(73)	0.08	(0.16)	0.04	(0.07)
Extracting	389	(93)	0.40	(0.79)	0.27	(0.54)
Pasteurizing/Homogenizing	62	(15)	0	(0)	0	(0)
Cooling (1)						
Juice Products	221	(53)	0.03	(0.05)	0.02	(0.03)
Segments			0.01	(0.02)	0.01	(0.02)
Juice Condensing	400	(96)	0.06	(0.12)	0.02	(0.03)
Barometric Condensing (2)						
Juice Products	50	(12)	0.07	(0.13)	0.09	(0.17)
Waste Heat Evaporator	71	(17)	0.15	(0.29)	0.09	(0.18)
Peeled Fruit Washing	129	(31)	0.04	(0.07)	0.01	(0.01)
Caustic Treatment	1	(0.3)	0.01	(0.02)	0.01	(0.01)
Centrifuging	144	(35)	3.07	(6.14)	0.51	(1.02)
Container Washing	75	(18)	0		0	(0)
Waste Heat Evaporator Condensate	334	(80)	0.33	(0.66)	0.11	(0.22)
Waste Heat Evaporator Scrubber Effl.	351	(84)	0.22	(0.43)	0.08	(0.15)
Oil Lean Residue From Separator	126	(30)	0.16	(0.32)	0.25	(0.49)
Boiler Blowdown	60	(14)	0.01	(0.02)	0.01	(0.02)
Regeneration Brine	13	(3)	0	(0)	0	(0)
Cleanup						
Juice Products	705	(169)	0.16	(0.32)	0.16	(0.31)
Segments	371	(89)	0.36	(0.72)	0.07	(0.13)
Peel Products	484	(116)	0.07	(0.14)	0.11	(0.22)

(1) 90% recirculated
(2) 2% cooling tower blowdown


CITRUS
RECEIVING/SORTING
FRUIT CLEANING
1
SEGMENTS
EXTRACTING
2
PEEL
PEEL
WATER-OIL EMULSION
FINISHING
FINISHING
SLUDGE
A
SOLIDS FROM
WASTE TREATMENT
CONCENTRATED JUICE
SINGLE STRENGTH
CENTRIFUGING
6
JUICE CONDENSATE
3
BAROMETRIC CONDENSER
4
PACKAGING
CONTAINER WASHING
5
PASTEURIZING
6
PACKAGING
CONTAINER WASHING
5
COOLING
7
TO CONSUMER
GRINDING
LIME
SCRUBBER
WATER
CONDENSATE
WASTE HEAT
EVAPORATOR
18
WASTE EFFLUENT TRANSPORT

	1 kkg	G/T
1 FRUIT CLEANING	305	73
2 EXTRACTING CLEANUP	386	93
3 JUICE CONDENSATE	401	96
4 BAROMETRIC CONDENSER	50	12
5 CONTAINER WASHING	75	18
6 PASTEURIZING	63	15
7 COOLING	221	53
CAUSTIC TREATMENT/WASHING	130	31
COOLING	63	15
REGENERATION BRINE	13	3
CLEANUP (JUICE PRODUCTS)	705	169
CLEANUP (SEGMENTS)	371	89
WASTE HEAT EVAPORATOR SCRUBBER EFFLUENT	351	84
WASTE HEAT EVAPORATOR CONCENSATE	334	80
WASTE HEAT EVAPORATOR BAROMETRIC CONDENSER	71	17
WATER-OIL SEPARATION	125	30
CLEANUP (PEEL PRODUCTS)	484	116

TOTAL WATER 4,150 l/kkg 994 G/T

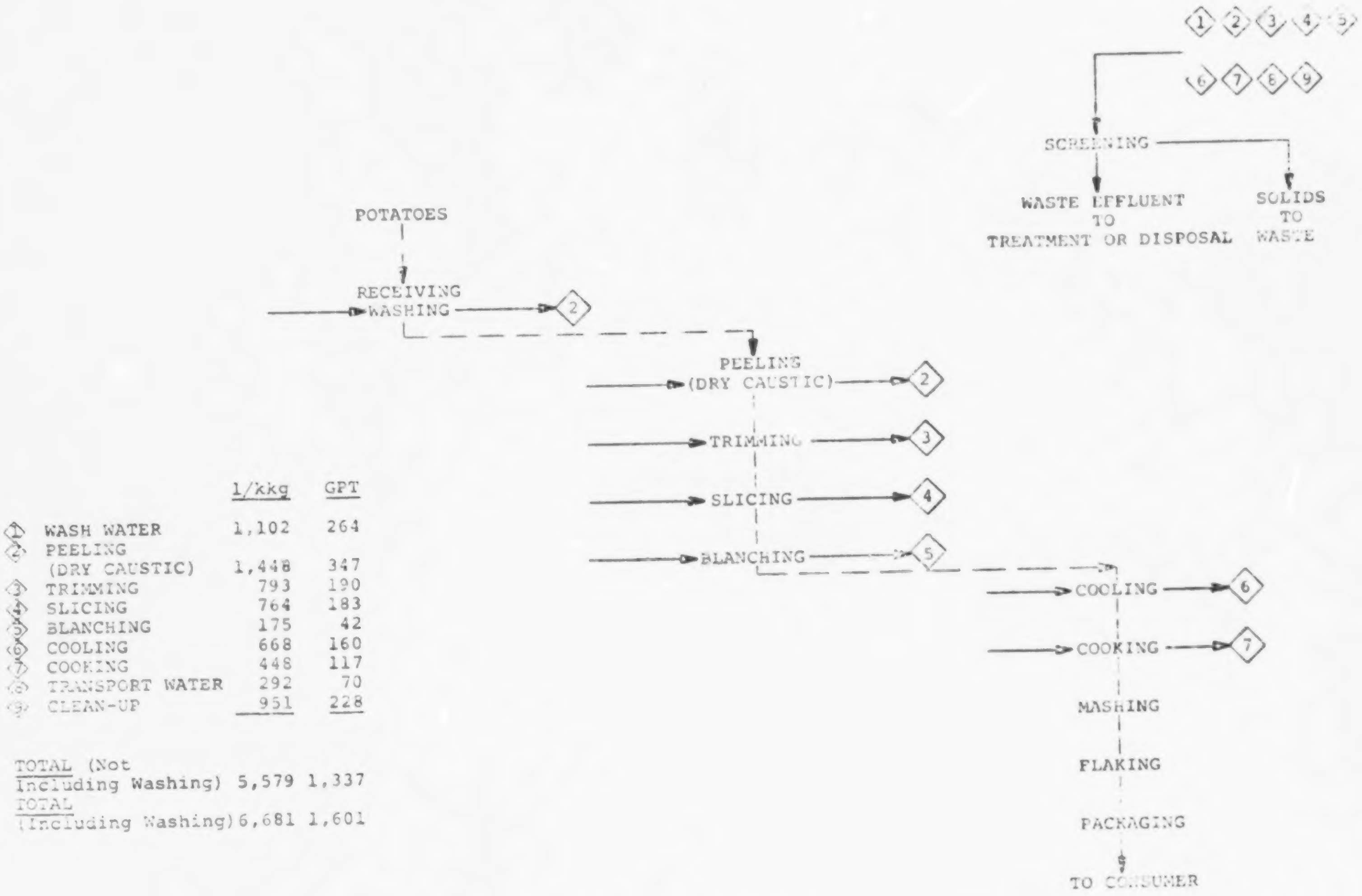
FIGURE 7 WATER FLOW DIAGRAMS - JUICE, OIL, SEGMENTS, AND PEEL PRODUCTS

TABLE 24

POTATOES

Water Usage and Waste Characterization In Potato Processing

Process Steps	Water Usage		BOD5		Suspended Solids	
	l/kkg	G/T	kg/kkg	lb/T	kg/kkg	lb/T
Washing	1,102	264	0.676	1.35	1.383	2.76
Peeling						
Dry Caustic	1,448	347	7.325	14.62	9.569	19.1
Wet Caustic	3,000	719	20.245	40.41	28.662	57.2
Steam	2,391	573	15.215	30.37	13.427	26.8
Trimming	792	190	0.777	1.55	0.26	0.52
Slicing						
Dehydrated	764	183	0.296	0.59	0.701	1.4
Frozen	1,519	364	2.630	5.25	1.303	2.6
Blanching						
Dehydrated	175	42	0.701	1.40	0.601	1.2
Frozen	1,043	250	5.461	10.9	2.104	4.2
Cooling	668	160	1.172	2.34	-	-
Cooking	448	117	1.192	2.38	-	-
Dewatering	513	123	0.471	0.94	0.351	0.70
Fryer Scrubber	417	100	-	-	-	-
Fryer Belt Spray	417	100	-	-	-	-
Refrigeration	1,602	384	-	-	-	-
Transport Water	292	70	0.261	0.52	-	-
Cleanup	951	228	2.725	5.44	-	-



1 2 3 4 5
6 7 8 9
SCREENING
WASTE EFFLUENT TO TREATMENT OR DISPOSAL
SOLIDS TO WASTE
POTATOES
RECEIVING WASHING
2
PEELING (DRY CAUSTIC)
2
TRIMMING
3
SLICING
4
BLANCHING
5
COOLING
6
COOKING
7
MASHING
FLAKING
PACKAGING
TO CONSUMER

	1/kkg	GPT
1 WASH WATER	1,102	264
2 PEELING (DRY CAUSTIC)	1,448	347
3 TRIMMING	793	190
4 SLICING	764	183
5 BLANCHING	175	42
6 COOLING	668	160
7 COOKING	448	117
8 TRANSPORT WATER	292	70
9 CLEAN-UP	951	228
TOTAL (Not Including Washing)	5,579	1,337
TOTAL (Including Washing)	6,681	1,601

FIGURE 8 WATER FLOW DIAGRAM - DEHYDRATED POTATO FLAKES

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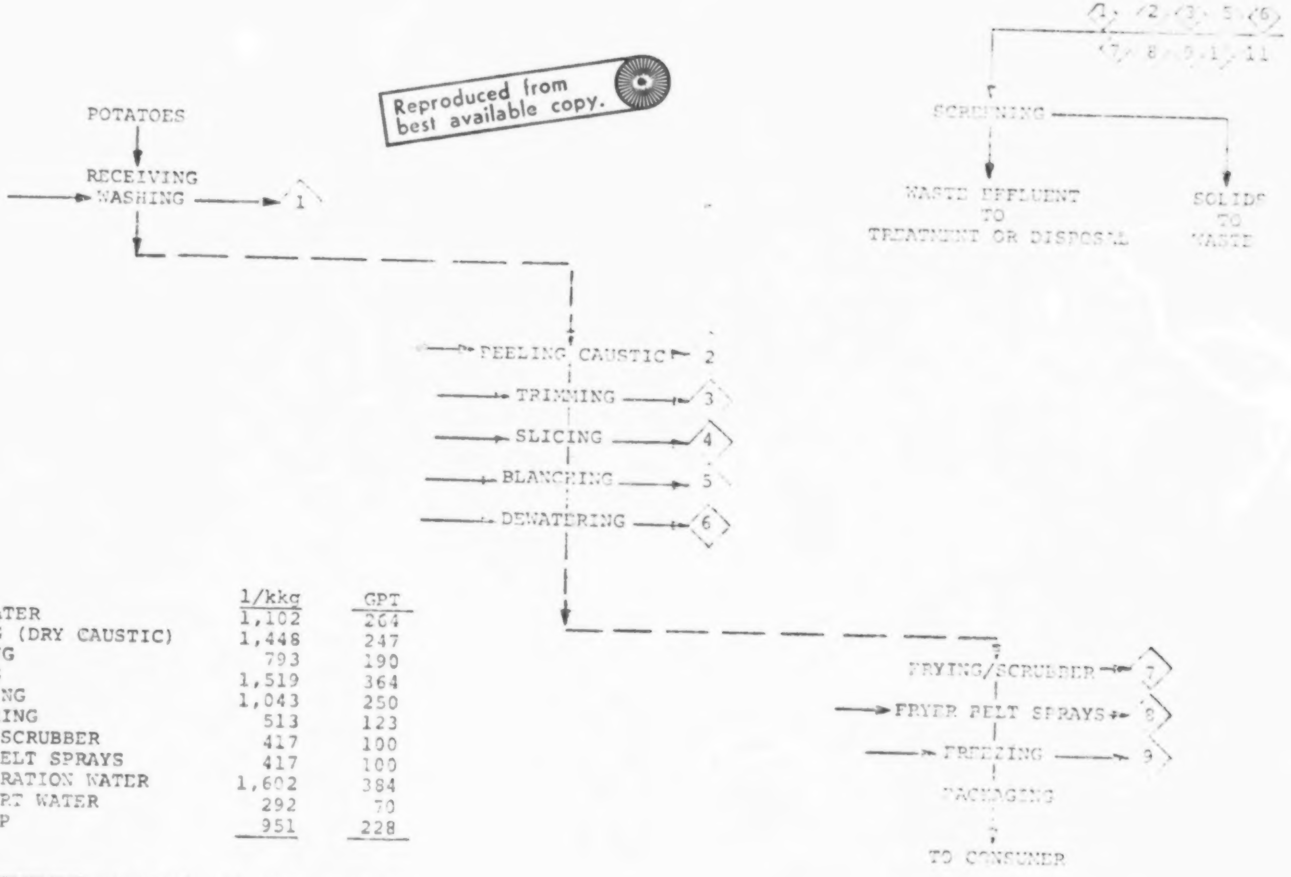
POTATOES
RECEIVING
WASHING
1
PEELING CAUSTIC
2
TRIMMING
3
SLICING
4
BLANCHING
5
DEWATERING
6
FRYING/SCRUBBER
7
FRYER BELT SPRAYS
8
FREEZING
9
PACKAGING
TO CONSUMER
1 2 3 5 6
7 8 9 1 11
SCREENING
WASTE EFFLUENT TO TREATMENT OR DISPOSAL
SOLIDS TO WASTE

	1/kkg	GPT
1 WASH WATER	1,102	264
2 PEELING (DRY CAUSTIC)	1,448	247
3 TRIMMING	793	190
4 SLICING	1,519	364
5 BLANCHING	1,043	250
6 DEWATERING	513	123
7 FRYING SCRUBBER	417	100
8 FRYER BELT SPRAYS	417	100
9 REFRIGERATION WATER	1,602	384
10 TRANSPORT WATER	292	70
11 CLEAN-UP	951	228
TOTAL (NOT INCLUDING WASHING)	10,492	2,516
TOTAL (INCLUDING WASHING)	10,091	2,420

FIGURE 9 WATER FLOW DIAGRAM - FROZEN POTATO PRODUCTS

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

WASTE WATER PARAMETERS OF MAJOR SIGNIFCANCE

A thorough analysis of the literature, industry data and sampling data obtained from this study, and EPA Permit data demonstrates that the following waste water parameters are of major pollutional significance for the apple, citrus and potato processing segment of the canned and preserved fruits and vegetables industry:

Biochemical Oxygen Demand (5-day, 20° C., BOD5)
Suspended Solids (SS)
pH

Rationale for Selection of Major Parameters

Biochemical Oxygen Demand

This parameter is an important measure of the oxygen utilized by microorganisms in the aerobic decomposition of the wastes at 20°C over a five day period. More simply, it is an indirect measure of the biodegradability of the organic pollutants in the waste. BOD5 can be related to the depletion of oxygen in a receiving stream or to the requirements for waste treatment.

If the BOD5 level of the final effluent of a processing plant into a receiving body is too high, it will reduce the dissolved oxygen level in that stream to below a level that will sustain most fish life; i.e. below about 4 mg/l. Many states currently restrict the BOD5 of effluents to below 20 mg/l if the stream is small in comparison with the flow of the effluent. A limitation of 200 to 300 mg/l of BOD5 is often applied for discharge to municipal sewer, and surcharge rates often apply if the BOD5 is above the designated limit.

Suspended Solids

This parameter measures the suspended material that can be removed from the waste waters by laboratory filtration, but does not include coarse or floating matter than can be screened or settled out readily. Suspended solids are a visual and easily determined measure of pollution and also a measure of the material that may settle in tranquil or slow moving streams. A high level of suspended solids is an indication of high organic pollution.

pH

pH is an important parameter for providing in-process quality control for recycling of process water. Biological treatment systems operate effectively at a pH range between 6.0 and 9.0. These systems can be rendered ineffective by intermittent dumping of highly acidic or highly alkaline wastes such as caustic tanks used for peeling.

Rationale for Selection of Minor Parameters

Chemical Oxygen Demand (COD)

COD is another measure of oxygen demand. It measures the amount of organic and some inorganic pollutants under a carefully controlled direct chemical oxidation by a dichromate-sulfuric acid reagent. COD is a much more rapid measure of oxygen demand than BOD_5 and is potentially very useful.

COD provides a rapid determination of the waste strength. Its measurement will indicate a serious plant or treatment malfunction long before the BOD_5 can be run. A given plant or waste treatment system usually has a relatively narrow range of COD:BOD_5 ratios, if the waste characteristics are fairly constant, so experience permits a judgment to be made concerning plant operation from COD values. In the industry, COD ranges from about 1.6 to 10 times the BOD_5; the ratio may be to the low end of the range for raw wastes, and near the high end following secondary treatment when the readily degraded material has been reduced to very low levels.

In summary, BOD and COD measure organic matter which exerts an oxygen demand. Both COD and BOD are useful analytical tools for the processor. However, no COD effluent limitations are required because BOD limitations have been established.

Total Dissolved Solids (TDS)

The dissolved solids in waste water are mainly inorganic salts. They are particularly important as they are relatively unaffected by biological treatment processes and can accumulate in water recirculation systems. Failure to remove them may lead to an increase in the total solids level of ground waters and surface water sources. The dissolved solids in discharge water, if not controlled, may be harmful to vegetation and may also preclude various irrigation processes. There is not sufficient data available to establish effluent limitations for TDS, but at land treatment systems TDS must be managed to insure satisfactory performance without damage to the physical properties of the soil or to the quality of the ground waters.

Alkalinity

The measure of alkalinity is an indicator of bicarbonate, carbonate and hydroxide present in the waste water. The alkalinity of water appears to have little sanitary significance. Highly alkaline waters are unpalatable, and may adversely affect the operation of water treatment systems. However, pH limitations require the control of alkalinity, thus, no alkalinity limitations are needed.

Ammonia Nitrogen and Other Nitrogen Forms

Neither apple, citrus or potato effluents contain significant quantities of nitrogen. The three most common forms of nitrogen in wastes are organic, ammonia and nitrate. Organic nitrogen will break down into ammonia, nitrogen and nitrate. When ammonia nitrogen is present in effluent waste water, it may be converted to nitrate nitrogen by oxidation. When ammonia and nitrates are added to ponds and lakes, they contribute to euthrophication. Since fruit and vegetable wastes are generally deficient in nitrogen, no nitrogen limitations are required.

Total Phosphorus

Phosphorus, like nitrate, is linked directly to the eutrophication process of lakes and streams. Sampling shows no significant levels of phosphorus in apple, citrus or potato waste water. When applied to soil, phosphorus does not exhibit a runoff potential because it is readily absorbed tenaciously on soil particles. In this case, movement of phosphorus to ground water is essentially precluded and runoff can only occur if actual erosion of the soil takes place. Since fruit and vegetable waste waters are generally deficient in phosphorus, no phosphorus limitations are needed.

Fecal Coliforms

Significant numbers of fecal coliforms are generally not found in apple, citrus or potato waste waters unless sanitary waste is mixed with process waste. In order to insure that the bacteriological quality of waste waters does not create a problem all sanitary wastes should be handled separately from process waste waters. Because coliforms are not a major constituent of the raw waste water and because in-plant reuse of water, waste water retention and land disposal minimize bacteriological problems, fecal coliform effluent limitations are not required.

Temperature

The temperature of effluent waste water is important, since release of water at elevated temperatures into surface or ground water formations could result in damage to the micro-ecosystems. The design of treatment facilities is also dependent upon the plant effluent temperature.

However, high temperature wastes are not associated with apple, citrus, or potato processing. Thus, guidelines for temperature are not needed.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

INTRODUCTION

The characterization of the waste effluents has provided a specific description of the waste streams resulting from the food processes, involving identification of the origin of the various waste streams in the process, as well as waste water quality and quantity. This permits identification of the process steps which are the major contributors to the flow and waste loadings of the total waste effluent stream. Comparisons can be made between similar or alternative operations in other processing facilities that perform the same function but produce differing amounts of waste. The data provide information for consideration of in-plant separation of the most significant waste streams for separate treatment within the processing plant and also provide valuable insight into the properties of the wastes present and indication of their treatability.

IN-PLANT TECHNOLOGY

Waste characterization studies cannot be adequately discussed without a basic conception of the sources of wastes generated in apple, citrus and potato processing. A discussion of the eight basic sources of wastes are presented herein. It must be realized, that there are many process variations within production operations and all eight waste sources may or may not be present. However, when required by production operations each process is present regardless of size, age, or location of plant.

Harvesting

This operation can be defined as removal of the product from its growing environment, its collection and its transportation to the processing plant. The present systems of picking include combinations of human effort and machine utilization with a gradual, but steady, increase in the latter. The increased use of mechanical means of picking has increased the amounts of soil and organic solids included with the product, and has resulted in a higher organic load from damaged or spoiled raw products. This trend has also increased the amounts of water necessary for washing and cleaning the product. Current studies have suggested the possibility of relieving the waste load at fruit and vegetable processing plants by field washing techniques. The use of economically feasible and aesthetically acceptable procedures for sorting, cleaning and sanitizing these crops in the field has many potential advantages. Rejected raw product, plant materials, field soil, and wash waters remain in the field. Waste disposal there can be by methods both simpler and less costly than the methods available for waste materials hauled into urban communities.

This technique is only suitable for the raw material which needs to be processed right after harvesting. For example, the tomato industry has applied this technique very successfully. But as far as the three discussed commodities, only citrus has the possibility to adapt this method. Apples and potatoes both are usually placed into storage after harvesting for processing later in the season; and storage of wetted raw crops will increase the possibility of spoilage. The technique, if applied to citrus, would reduce water and waste loadings only a small amount. Therefore it is not practical to apply field washing techniques for these commodities.

Raw Material Cleaning

After harvesting, the raw material (such as apples or potatoes) either is placed into storage or goes directly to the processing plant. Fruit is often given a preliminary washing to remove soil and organic materials before preparing for processing. A common method is to drop the product directly into water which acts as a cushion for unloading the fruit. The raw material is separated from much of the remaining leafy and stem material, soil residues, seeds, and pesticide residues. After this initial wash, the raw material cleaning operations contribute minor pollutants to the waste water.

Apples and potatoes are stored for processing later in the season. If the storage house is located in a different area from the processing plant, the raw material could be washed as it is withdrawn from storage and sorted for the fresh market. This way, the waste load at the processing plant could be reduced.

In the case of potatoes, the increased mechanization of harvesting has increased the quantity of soil or dirt pickup at harvest. These increased soil loads can require more thorough water washing or alternate cleaning systems. Therefore, if the washing is done at a storage site removed from the processing plant, it could save approximately 8 percent of the total water usage at the processing plant and eliminate the need or at least reduce the size of the silt pond.

Peel Removal

In the case of the fruits, apple and citrus, where it is necessary to remove the peel, the conventional system employs a mechanical means of peel removal.

In citrus processing, the manufacture of segments involves a hot lye treatment to remove the rag and membrane from the whole peeled fruit prior to sectionizing. This hot alkaline treatment, also, results in an excessive waste effluent load. Less than 15 percent of the total citrus harvest is sectionized and receives a caustic treatment.

The peeling of potatoes generates higher waste loads than those which are produced by either the apple or citrus peeling operations. In the potato processing industry, excluding potato chip manufacture, there are two generally accepted methods of peel treatment, caustic and steam. In the case of the caustic, either a hot dip or hot spray contact can be used. In the dry caustic system, the alkaline solution is baked into the skin of the potato prior to peel removal.

Water sprays or rubber abrading (USDA development) are the two principal means of removing the loosened peel following treatment. If the peel is removed by water sprays, then the waste effluent load in the water system is increased; however, if the loosened peel is removed by rubber abrading and brushing with added water, the peel is collected as a slurry and may be disposed of as animal feed. Different treatment and peel removal operations do not significantly affect the waste effluent load based on data from Section IV. However, information from vendors and other sources indicates that peeling represents 20 percent of the effluent flow, over 50 percent of the BOD and over 60 percent of the SS. In addition, when the USDA scrubbers are utilized, peel wastes are only half as great.

Almost all frozen potato products, french fries, hash browns, etc., are caustic treated prior to peeling. The caustic system (either wet or dry) is used because of the thorough peeling required for these products. Dehydrated potato products are peeled with either the caustic or steam peel system.

Sorting, Trimming & Slicing

Sorting and grading operations may take place at various points in the process prior to packaging and may occur more than once in the same process. The primary purpose of these operations is to remove those pieces with undesirable blemishes or grade or sort for size and shape.

Separations as to quality of the product are most often done by hand, while size separations are done by mechanical means. Wastes from these operations consist of whole pieces, miscellaneous organics and juice. Trimming operations are defined as the removal of unwanted portions of the product. These wasted portions consist of blemishes, cores, pits, and peels. Blemish removal is done by hand and results in waste products consisting of pieces and juice. Cores and pits are most often removed mechanically.

In the processing of apples, the water exposed to the interior of the fruit, apple slices or dices, as they are cut, washed, or transported, can be recirculated for a given period of operation, thus allowing the soluble and suspended solids to build up in the water system. When it is necessary to replace this water because of product quality, the contaminated water can be further concentrated by evaporation and then used as a vinegar stock. Of course, the above system really only applies to the manufacture of apple slices. In the manufacture of sauce, the apple pieces are cut and dropped directly into the cooker, thus, as in the manufacture of cider, little BOD_5 is generated.

In the sorting or trimming process, only in the citrus sectionizing process does the interior of the fruit contact the water used for fluming.

In the processing of the potato, the cutting (slicing) of the potato frees quantities of starch which is washed from the potato pieces into the wash or slicing water. If this water is maintained at ambient temperatures and recirculated within the system, it is possible to remove with cyclones a concentrated stream of crude starch as it is built up in the recirculated water. This starch slurry can be sold to potato starch processors as a starting raw material. This system (removal of starch from slicing and washing water) is currently being employed on a small scale by several potato processors.

Transport

Various means have been adopted for conveying fruit or vegetable products at unloading docks into and through the process plant. These include fluming, elevating, vibrating, screw conveyor, air propulsion, negative air, hydraulic flows and jet or air blast. Among them, flume, belt, and pump transport systems are the most common means. Water, in one way or another, has been extensively used in conveying products within plants because it has been economical and because it serves not only as conveyance but, also, for washing and cooling. It is also assumed that there was some sanitary significance for both product and equipment. Therefore, flume transport requires much greater quantities of water than either of the other two common methods and produces correspondingly greater waste volumes, as well as resulting in greater leaching of organics into waste stream, such as sugars and acid from cut apples, and starch from cut potatoes. Since the extent of leaching is a function of contact time in the fluid, it would behoove the processor, from a loss-minimization standpoint, to keep product detention time in such flumes to a minimum. Usually the transport water is reused by recycling.

Pumping, employing a high percentage of recirculated water, is almost always used for transporting these three commodities. The increasing importance of waste water treatment has focused attention on alternate conveying systems. Air conveying eliminates the use of water, but it is only suitable for raw materials of small size and not easily damaged, such as peas. Air conveying is not practical for the three commodities under consideration. Most likely, a mechanical belt system will replace many of the flume systems. A small amount of chlorinated water is needed to spray on the belt for sanitation purposes during the operation. Also, it is necessary, through the use of brushes, vapors and water sprays, to prevent the buildup of organic material in the conveyor system.

In many instances, the transport water is also used to cool the product after blanching or to wash the pieces after a cutting operation or to prevent oxidation of the product. In this manner, the transport water serves a dual or multi-purpose function. Thus, the particular water transport system must be carefully evaluated before conversion to a mechanical conveying system.

Blanching

The blanching of vegetables and some fruits for canning, freezing or dehydrating has several purposes:

1. Elimination of intercellular air to reduce or eliminate subsequent oxidation.
2. Removal of starch and the inactivation of enzymes.
3. Destruction of bacteria.
4. Improvement of product texture.
5. Reduction of color loss in subsequent operations.

Vegetables are blanched either in water or in steam at various temperatures and times. Water blanching is generally used for canned vegetables and steam blanching for frozen or dehydrated vegetables.

Vegetables are water blanched prior to canning in order to remove air and to leach solubles for clarity of brine. These are factors appearing in the USDA grades of canned vegetables. For freezing and dehydrating, destruction of enzymes is more important. Blanching in water removes more solubles, including minerals, sugars and vitamins, than does steam blanching. Steam blanching will in many instances use less water and have a greater yield of product than water blanching because of a reduced amount of leaching that takes place.

In European food processing plants, the blancher water is often recirculated to permit a buildup of soluble solids within the water system. This procedure will decrease the product loss, but it can also adversely affect the removal of undesirable leachables from the product.

The pollution loads from blanching are a significant portion of the total pollution load in the effluent stream during the processing of certain vegetables. The blanching of potatoes may contribute over 20 percent of the BOD waste load.

In addition to the conventional hot water and steam blanching methods, a number of alternative methods have been explored in an effort to reduce the waste water volume derived from this process. Fluidized bed blanching and IQB (individual quick blanching) have been investigated, but neither appears to have the potential for almost complete elimination of waste water. Hot air blanching has received periodic interest, but the requirement of recirculating large volumes of air and, also, the high energy costs have hindered the commercial development of this concept. More recently, microwave and hot gas blanching (based on the direct use of hot natural gas combustion products as the major heat source) have shown promise for substantially reducing the volume of waste water while providing commercially acceptable blanching. The capital costs of microwave blanching are too high for a seasonal operation. Blanching is not required in many apple and citrus operations and the low water volume methods discussed would be less applicable to products such as potatoes, where a desirable function of hot water blanching is the removal of some of the leachable soluble solids.

Another possibility which was considered was to not only to clean, but, also, to blanch the vegetable products at decentralized locations close to harvest areas. The blanched product then would be cooled and transported to a centralized plant for either canning or freezing. This processing concept has the advantage of using spray irrigation for the disposal of the blanching waste load to areas which are more readily available and acceptable.

Can Rinsing and Cooling

The product is transported to the canning department where it is placed in containers which are then filled with juice, syrup or brine. Spillage of product and liquid are the major waste sources in the packing operation.

To seal the containers under vacuum, open cans are heated to expel air. Additionally, some products are cooked in the can in continuous cookers. After such heat-producing treatment, the sealed cans must be cooled and water from a recirculated water system is commonly used for this purpose. Little organic contamination of the water occurs, but very large volumes are required. From 11 to 26 percent of the plant water flow may be required in the can cooling operation.

Cleanup

Wastes resulting from periodic house cleaning are generated from every portion of the process. Due to their short term and transient nature, they are almost impossible to characterize individually.

In a typical apple, citrus or potato processing plant up to 35 percent of the total waste load may originate from the clean-up operations. The amount and strength of wastes generated in clean-up will depend upon the age, condition and layout of the plant as well as the specific operating practices employed. Some of the many techniques used to control waste generation from clean-up activities are listed below. Most are presently used in the food processing industry; each of them is applicable.

1. High pressure nozzles with specially designed nozzels to minimize water use.

2. Automatic shut-off on clean-up hoses so that water flow stops when the hose is put down.

3. Automatically timed clean-up cycles where the water flow shuts down after predetermined interval.

4. Automatic cleaning of conveyers, piping and other equipment wherever possible.

5. The use of squeeges in place of water for cleaning up spilled solids.

6. Cleaning gutters of solids promptly before solubles can be leached into the water.

7. Pulling the drain bracket only after cleanup has been completed.

8. Separation of flows from various cleanup operations.

9. Automatic monitors that alert plant management to increases in waste flow for strength attributable to improper cleanup practices.

10. One plant has an employee whose full-time responsibility is to monitor cleanup operations and to minimize water use and waste generation.

11. The use of special cleanup crews, specifically trained for this function.

12. Minimum use of water and detergent, consistent with cleaning requirements.

The clean-up for apple processing is much higher than for either citrus or potatoes. This is attributed to the method of operations used in apple processing where there is often excessive spillage of wastes on the floor from mechanical peelers. This waste is periodically cleaned up once or twice a shift. There are low waste loads attributable to mechanical peeling and this load represents only the transport water associated with this process step. Much of the waste load is generated after shutdown of operations when the plant is cleaned up.

In the case of potatoes and citrus, the processing plants usually operate nearly 24 hours per day. Consequently, there is a tendency toward continuous clean-up, rather than a separate clean-up shift as in the case of apples.

In-Plant Reuse of Water

A number of studies have been made in the food processing industry related to the possible in-plant reuse of water. The results of these studies indicate that the acceptability of procedures for reuse of water in processing operations requires such consideration as:

1. Water is an excellent solvent and is readily modified, chemically, physically, and microbiologically for its intended use. A particular use may or may not render water suitable for upstream application, such as fruit or vegetable washing. Recovered downstream, the water may be suitable for further use only when given enough treatment to be considered as a potable water.
2. The soil, organic or heat loads, in the used water may be such that considerable treatment is necessary to render it suitable for reuse.

Water recirculation using cooling towers is a common method of water conservation in food packing plants. Cooling tower blow-down can be used for supply water with the various subprocesses, and evaporator waters may be reused for processes such as initial washing.

Perhaps the most extensive work on feasibility in reuse of water has been done with "counter-current" flow systems. An example is the use of cooling water to wash products following blanching, and this water in turn used for initial washing of incoming raw product or the blanching of the product and then washing the incoming raw material. Consideration has been given to segregation of various waste waters in the process plant for immediate reuse or reuse after suitable treatment for certain operations. Due to bacteriological and product quality considerations, the treatment required for reuse of the water may be relatively simple, such as chlorination and screening, or, may become quite involved, requiring sedimentation, flocculation, and filtration or other unit operations.

Multiple use of water is being applied in commercial processing of fruits and vegetables. This has unquestionably permitted conservation of water and greater efficiency in the treatment required for the total plant effluent. However, in some instances it has not reduced the total amounts of organics being generated per ton of product.

In some citrus processing plants, the recycling of can-cooling water, barometric condenser water, refrigeration cooling water, water for pump seals, and cooling water for heat exchangers are all being successfully recycled. There are two factors to be considered in conditioning any waste water for reuse:

1. The economic factor, that is, the cost of fresh water versus the cost of treating and recirculating it for reuse, and the cost of disposal of waste water following its use.

2. The acceptability of the treated water for its intended use. The costs for treatment of water depend on the condition of the water and the treatment required to recondition it. If the water has acquired salt, sugar, starch, acids, or other organic or suspended materials, extensive treatment may be necessary. On the other hand, such treatment may be necessary anyway to reduce the total effluent degradation, or because such effluent cannot be discharged into either municipal systems or navigable water systems without treatment.

A reduction in water use within the process plant does not always reflect immediately an equivalent reduction in the waste load being generated. Accordingly, a few processors may not realize immediate benefits from a water reuse program. However, as more stringent waste effluent limitations are set and the industry moves closer to zero discharge of pollutants, the reduction in the water usage will reflect in lower investment and operating costs for disposal of wastes.

Many of the in-plant controls described above are presently practiced at apple, citrus and potato plants. From Section V (Tables 19-21), there are several plants that have exemplary raw waste loads. An apple sauce, slice, and juice plant has a raw waste BOD of 1.4 kg/kkg (2.8 lb/ton) compared to the average of 5 kg/kkg (10 lb/ton). A citrus juice, oil and feed processing plant has a water usage of only 710 l/kkg (170 gal/ton), BOD of 0.45 kg/kkg (0.9 lb/ton) and SS of 0.02 kg/kkg (0.04 lb/ton). These values compare with average flow values of 10,120 l/kkg (2425 gal/ton), average BOD of 3.2 kg/kkg (6.4 lb/ton) and average SS of 1.3 kg/kkg (2.6 lb/ton). A frozen potato plant has a water usage of 4090 l/kkg (980 gal/ton) and a BOD of 4.45 kg/kkg (8.9 lb/ton) compared with average values of 11,300 l/kkg (2710 gal/ton) and 22.9 kg/kkg (45.8 lb/ton). Thus, there are processors achieving high levels of pollutant reduction through in-plant waste management techniques.

The exemplary raw waste loads described above are applicable to the best available technology economically achievable. However, exemplary waste water treatment systems currently operational at processing plants have been used to determine the best available level of effluent reduction. While these in-plant controls are not required to meet the standards, their utilization is encouraged.

WASTE TREATMENT TECHNOLOGY

PRELIMINARY TREATMENT SYSTEMS

In modern cannery practice there has been an almost uniform acceptance of the need for separating solid wastes from the principal effluent waste stream. Treatment processes employed in this separation are physical in nature and include screening, plain sedimentation, hydroclones and flotation. These processes are applicable to all apple, citrus or potato plants regardless of size, age or location.

Flow Equalizing Tank

Flow equalization facilities consist of a holding tank and pumping equipment designed to reduce the fluctuations in flow of waste effluent streams. They can be economically advantageous whether a processing plant is treating wastes or discharging into a city sewer after some pretreatment. The equalizing tank stores waste water either for recycle or to feed the flow uniformly to treatment facilities throughout a 24-hour day period.

Screening

Screening is the most widely accepted method of preliminary treatment of cannery wastes. Ordinarily, its cost is nominal relative to the benefits derived in the reduced load on waste treatment or sewage facilities. However, it is not usually considered as an economic method of solids separation when high degrees of removal are required. Recent improvements in the fabrication of screen cloths are permitting smaller particulate matter to be removed. Also, the introduction of synthetic cloths (polyester, nylon, polyethylene) has resulted in low maintenance costs. Screens utilizing synthetic cloth with 5 to 10 micron openings are commercially available and have a good resistence to blinding.

Three types of screens have been used for screening food processing wastes: stationary, revolving, and vibrating. Most of the screens in current use are of the rotary type, but the vibrating screens have been favored because they tend to have fewer clogging problems, to provide a drier screenings discharge, and to produce more compact solids.

Nearly all processing plants use some form of screening. Primary screens are usually equipped with a screen cloth in the size range of 20 to 40 mesh. However, because of the industrial preference to use relatively simple, standard equipment, there has been a gradual shift in the direction of stationary wedge-wire screens with an equivalent mesh opening. This does not represent any real change with respect to the removal of solids for waste control.

Stationary Screens - The primary function of a stationary screen is to separate or "free" the solids from the transporting fluids. This can be accomplished in several ways, and in most older concepts only gravity drainage is involved. A concave screen has been designed using high velocity pressure-feeding. This design employs bar interference to the slurry which cuts off thin layers of the flow over the curved surface. This method can very effectively handle slurries containing fatty or sticky fibrous suspended matter. Openings between the bars or wires of 0.025 to 0.15 cm (0.010 to 0.060 inches) meet normal screening needs.

Rotary Screens - One type of barrel or rotary screen, driven by external rollers, receives the waste water at one open end and discharges the solids at the other open end. The liquid flows outward through the screen (usually stainless steel screen cloth or perforated metal) to a receiving box and effluent piping mounted below the screen with a line of external spray nozzles directed on the screen. This type is popular and may be useful in removing solids from waste streams containing low solids concentrations.

Vibrating Screens - The effectiveness of vibrating screens depends on a rapid motion. They operate between 900 rpm and 3600 rpm; the motion can either be circular, straight line, or three dimensional, varying from 0.08 to 1.27 cm (1/32 to 1/2 inch) total travel. The speed and motion are selected by the screen manufacturer for the particular application.

Most important in the selection of a proper vibrating screen is the use of the proper cloth. The capacities of vibrating screens are based on the percent of open area of the cloth. The cloth is selected with the proper combination of strength of wire and percent of open area. If the waste solids to be handled are heavy and abrasive, wire of a greater thickness and diameter should be used to assure long life. However, if the material is light or sticky in nature, the durability of the screening surface may be the smaller consideration. In such a case, a light wire may be necessary to provide an increased percent of open area.

The effectiveness of screening the raw waste load from a food processing plant is illustrated by the following examples:

1. A 24-mesh oscillating screen removed 60 percent of the suspended solids from a potato-carrot waste effluent.

2. A 28-mesh rotary screen removed 79 percent of the suspended solids from a tomato processing waste effluent.

There is a good deal of experimentation under way in the direction of better solids removal equipment which uses finer mesh screens. An example of this new technology is the micro-screen. The impact on this development on waste loads is difficult to assess at this time. The use of fine mesh screens such as the micro-screen will require some sort of pre-screening ahead of it to act as an insurance or protective device.

Grease Removal (Catch Basins)

Most waste treatment plants do not possess the facilities to handle large amounts of grease. Adequate grease trapping should be provided at the processing plant and, in some cases, emulsion breaking may be required to remove the oil and grease.

The presence of grease and related wastes often causes severe problems in the waste treatment facility. In one instance, the processing plant was producing french fried products, and many of the wastes generated in this process were highly emulsified, compounding the grease removal problem. Improved grease trapping facilities at various points in the plant were necessary to correct the problem.

In the past twenty years, with waste treatment gradually becoming an added economic incentive, catch basin design has been improved, the concern shifting toward overall effluent quality improvement and toward by-product recovery. Gravity grease recovery systems will remove 20 to 30 percent of the BOD_5, 40 to 50 percent of the suspended solids and 50 to 60 percent of the grease (hexane solubles).

Most gravity grease recovery basins (catch basins) are rectangular. Flow rate is the most important criterion for design; 30 to 40 minutes detention time at one hour peak flow is a common sizing factor. The use of an equalizing tank ahead of the catch basin obviously minimizes the size requirement for the basin. A shallow basin - up to 1.8m (6 feet) - is preferred. A "skimmer" skims the grease and scum off the top into collecting troughs. A scraper moves the sludge at the bottom into a submerged hopper from which it can be pumped.

Usually two identical catch basins, with a common wall, are desirable so operation can continue if one is down for maintenance or repair. Both concrete and steel tanks are used for the catch basin.

Flotation

A high percentage of the solids in carbonaceous food processing wastes can be removed by vacuum flotation. When wastes are subjected to a short period of aeration with 0.185 to 0.37 cubic meters of air per thousand liters (0.025 to 0.05 cubic feet of air per gallon) of waste effluent, then passed on to a compartment where the large air bubbles can escape, and finally the liquid is sent to a holding tank where it is subjected to a vacuum of about 0.27 to 0.33 atmospheres (8-10 inches of mercury). The solids quickly rise to the surface with the released small bubbles forming a relatively dense mat which is removed by mechanical skimmers.

There are three process alternatives varying by the degree of waste water that is pressurized and into which the compressed air is mixed. In the total pressurization process the entire waste water stream is raised to full pressure for compressed air injection. In partial pressurization, only a part of the waste water stream is raised to the pressure of the compressed air for subsequent mixing. In the recycle pressurization process, treated effluent from the flotation tank is recycled for mixing with the compressed air and then, at the point of pressure release, is mixed with the influent waste water. This alternative has a side-stream of influent entering the retention tank, thus reducing the pumping required in the total pressurization process. Operating costs may vary slightly, but performance is essentially equal among the alternatives.

Improved performance of the air flotation system is achieved by coagulation of the suspended matter prior to treatment. This is done by pH adjustment or the addition of coagulant chemicals, or both. A slow paddle mix will improve flocculation.

Since there are only a few installations of flotation units in the food processing industry, it must be recognized that experience with the application of this technique is limited.

One example of a flotation unit is in the treatment of tomato and peach waste water. Flows of 285,200 liters/square meter (7,000 gallons/square foot) of surface area per day were attained in this pilot installation, while removing 50 to 80 percent of the suspended solids.

Sedimentation

Sedimentation without prior chemical treatment has been used in the food processing industry. For example, a waste flow of 720,000-1,665,000 liters per day (190,000-440,000 gallons per day) was settled (after screening) in two concrete settling tanks 15.2 meters (50 feet) long by 3.7 meters (12 feet) wide by 0.9 meters (3 feet) deep with a detention time of about 1.5 hours. The settled sludge was allowed to accumulate to a depth of about 30.5 cm (12 in) over a 3 to 7 day period and was then removed and hauled to fields for disposal. Later improvements provided for continuous mechanical sludge removal from the settling tanks.

Sedimentation was used in this instance to reduce the solids loading on another part of the treatment process. It was found that sedimentation prior to lagooning lessened the odor from lagoons. Primary sedimentation has been found to reduce the BOD_5 between 50 to 80 percent and reduce the suspended solids between 30 to 75%, depending on the characteristics of the waste water.

An example of a dual sedimentation system is the potato processing industry where it is general practice to utilize primary sedimentation of the plant effluent and a separate sedimentation system for silt water. Potato wash water is reused after it has been pumped to a clarifier or holding pond for removal of settleable solids.

If settling tanks are used, the settled solids must be collected and withdrawn from the bottom of the tank. In municipal sewage treatment, the solids are continually collected by mechanical means through chain-driven wooden scrapers moving slowly along the bottom of the rectangular tank.

Centrifugal Separation

The centrifugal separation of cannery waste solids has not received wide acceptance in the food processing industry, apparently because of both high capital cost and high power cost. In some instances horizontal bowl centrifuges have been installed and in other instances hydroclones have been employed.

Hydroclones are experiencing the greater degree of acceptance than centrifuges because of low initial cost and operating cost. Currently, they are not only being installed on waste effluent streams to remove some of the organic solids but also on in-plant potato processing flows to recover crude starch slurries.

Centrifuges can probably remove at least as much BOD5 and suspended solids as does primary sedimentation. One potato processor has reported a BOD reduction of 1700 mg/l through the use of hydroclones in the waste effluent stream leaving the plant.

CHEMICAL TREATMENT

pH Adjustment

Caustic is often used in peeling potatoes and apples. The use of caustic may raise the pH of the total effluent enough to disrupt a biological treatment, in which case the pH is adjusted to avoid "slugging" the system with caustic. Although high pH accompanies lye peeling, processors handle peel wastes in a manner that does not affect the value of the solid waste as feed for livestock. Fruit, tomato, and root crops peeled in other ways may yield an effluent with neutral or low pH. Drastic fluctuations in pH occur when lye peeling tanks are dumped periodically and smaller fluctuations may result from the caustic solutions used in plant cleanup. The pH of the waste water can be adjusted by the addition of an acid, for instance, sulfuric acid.

Another situation requiring pH adjustment can arise when fruits contain acid and pectin, such as citrus or apples. In some biological systems trouble is encountered with bulking sludges associated with filamentous growth. Increasing the pH, for instance by adding lime, may correct the problem.

Biological systems function at their optimum when the pH is neutral (i.e. 7.0), and they will operate effectively at a pH range between 6.0 and 9.0.

Chlorination

Chlorination is, also, used for odor control and is chiefly used in municipal water treatment as a disinfectant and partially to reduce the BOD_5 of the treated effluent. (Biological processes should be relied on to provide BOD_5 reduction, rather than chlorination). Chlorine is available in powdered form, as liquefied chlorine, and in solutions. Adding chlorination to a treatment process presents the need to construct chlorine handling facilities consisting of storage, phase conversion, mixing, and detention facilities for effluent. Since chlorine is a hazardous substance, special safety precautions in storage and handling are required. Dose rates for chlorine for domestic sewage are usually in the range of 3 to 15 parts per million with detention times up to one hour in duration. Dosage should be high enough to provide a chlorine residual in the effluent to assure protection against pathogenic bacteria.

Chlorination is used to inhibit algae growth. This is of special importance for correcting one type of bulking sludge problem in some activated sludge plants.

Chlorination may also be used for disinfection and to oxidize residual organic material. It is practiced on treated wastewaters to a limited degree. This practice can be expected to become common to permit the recycle of highly purfied waters.

Chlorine, also, provides a residual protection against bacteria that other disinfectants, such as ozone or bromine, do not provide. Actual chlorination rates should be based on laboratory testing of the effluent.

Nutrient Addition

Cannery waste water is generally deficient in both nitrogen and phosphorus from the standpoint of the ratio of these elements to organic matter that is required for optimum biological treatment. This situation can be corrected by adding ammonia and phosphoric acid, for example, to the waste water before biological treatment. The chemicals should be added after initial screening and settling to avoid their loss to the solids removed in these steps.

Chemical Coagulation and Precipitation

Chemical precipitation of cannery wastes has been used with varying degrees of success. Investigators have reported reductions in BOD5 as high as 89 percent. In almost all instances lime was the coagulant used whether singularly or in conjunction with another coagulant or coagulant aid. Doses of coagulants required were much higher for food processing wastes than those required for domestic sewage alone, since the suspended solids concentrations in food processing wastes are much higher than domestic wastes.

Most chemical precipitation processes in use are batch type; some continuous processes have also been reported. With the fill and draw technique, a minimum of two tanks is required for treatment. This system has the advantage of permitting easy handling of large volumes of sludge. The continuous flow system has the disadvantages of minimum flexibility in maintaining optimum dosages and its inability to accommodate removal of large sludge volumes.

It has been reported that chemical precipitation gave smaller BOD5 removals than biological filtration, but that it, also, had some advantages compared to trickling filters. Biological filters required time to develop a satisfactory filter flora and had to be used continuously; whereas, chemical precipitation could be utilized immediately and intermittently. This is particularly advantageous in the seasonal canning industry.

In some processing plants, lime and alum were added to the waste effluents from pea processing prior to screening. This resulted in a 42 percent BOD5 removal and an 81 percent removal of the suspended solids.

Miscellaneous Chemical Additives

Chemical additives may also be added to waste waters to control foaming and to control odors and to enhance solid settling characteristics such as is accomplished by coagulating agents.

PRIMARY TREATMENT SYSTEMS

The typical primary treatment system operating in the food processing industry consists of a clarifier and rotary vacuum filter to remove and dewater the settled sludge from the waste effluent stream. Chemical precipitation may be used for those waste sludges that are not readily settleable, and suspended solids may be removed from effluents by the addition of an air flotation unit.

Settling, Sedimentation and Clarification

A substantial portion of the suspended solids that cannot be conveniently removed by screening can be separated by sedimentation, settling or clarification. Settling consists of providing a sufficiently large tank or pond so that the velocity of the water is reduced. The forces arising from density differences between the solids and the water can then act and the solids can settle. Clarifiers operate on the same principle with the addition of mild mechanical agitation to assist in the settling process and the removal of the settled solids. As an initial step preceding biological treatment, a combination of screening and clarification can be expected to remove 50 to 80 percent of the waste water BOD_5. With the addition of chemicals for coagulation BOD_5 removals range from 25 percent to 40 percent of raw influent and suspended solids removal range from 40 percent to 70%. It is, also, found that sedimentation prior to lagooning lessened the odor from lagoons. Clarifiers are, also, used as a part of the activated sludge process, serving to separate sludge for return to the aeration step or to anaerobic digestion. Settling ponds or clarifiers are, also, used as a final step in biological systems for the removal of solids prior to discharge of the treated wastewater. In the processing of apple or citrus waste effluents, the presence of pectin often restricts the removal of solids by clarification. Therefore, sedimentation is less frequently practiced in these industries than in the potato industry.

Rotary Vacuum Filtration

The settled solids removed from the bottom of the clarifier, in the form of a sludge, are pumped to the rotary vacuum filter, where the slurry is concentrated by removal of water which is returned to the clarifier. The outside surface of the filter cylinder is covered with a filter medium (cloth). The lower portion of the filter is suspended in the liquid slurry. As the drum rotates, the vacuum maintained within the cylinder forces fluid into the cylinder leaving a layer of solids on the outside filter medium. As the filter rotates, the solids are scraped off from the cloth. This method has been widely used in solids thickening for both industrial and municipal wastes.

The dewatered solids are then discarded by one of the ultimate disposal techniques or used for animal feeds, and the water is recycled back to the clarifier.

BIOLOGICAL TREATMENT SYSTEMS

The treatment of waste effluents by biological methods is an attractive alternative when a high proportion of the biodegradable material is in the soluble form, as is the case in the canned and preserved fruits and vegetables industry. These methods are applicable in this industry irrespective of plant size, age or location.

Many types of microoganisms remove organic materials from liquid wastes. Those most commonly used in treatment systems are heterotrophs, which utilize organic carbon for their energy and growth. Some are aerobic and require molecular oxygen for converting wastes to carbon dioxide and water. Others are anaerobic and grow without molecular oxygen. Anaerobic microorganisms grow more slowly than aerobes and produce less sludge per unit of waste treated than do aerobic microorganisms. Anaerobes, also, release acids and methane, and their action on sulfur-containing wastes may create odor problems. Some microorganisms are facultative; that is, they can grow in either an aerobic or anaerobic environment.

The biological treatment of food processing wastes often lacks necessary nutrients in the waste to sustain desirable biological growth. Added nutrients, most often nitrogen and sometimes phosphorus, may be required for efficient biological treatment of food processing wastes. Processing wastes generally requires the addition of nitrogen before successful biological treatment. Often this can be economically accomplished by the addition of nutrient-rich wastes from another source for combined treatment.

A discussion of the various methods of biological treatment is presented in the following sections.

Activated Sludge

In this case the active biota is maintained as a suspension in the waste liquid. Air, supplied to the system by mechanical means, mixes the reaction medium and supplies the microorganisms with the oxygen required for their metabolism. The microorganisms grow and feed on the nutrients in the inflowing waste waters. There are fundamental relationships between the growth of these microorganisms and the efficiency of the system to remove BOD$_5$.

A number of activated sludge systems have been designed, all of which have their own individual configurations. Basically, these designs consist of some type cf pretreatment, usually primary sedimentation, and aeration, followed by sedimentation which will allow the sludge produced to separate, leaving a clear effluent. Portions of the settled sludge are recirculated and mixed with the influent to the aeration section, usually, at a proportion ranging between 10 to 100 percent, depending upon the specific modification ot the basic activated sludge process.

The goal of these plants is to produce an actively oxidizing microbial population which will also produce a dense "biofloc" with excellent settling characteristics. Usually, optimization of floc growth and overall removal is necessary since very active microbial populations do not always form the best flocs.

Activated sludge treatment plants are capable of removing 90 to 95 percent or better of the influent BOD_5 from fruit and vegetable processing plants.

Activated sludge systems will remove over 95 percent BOD_5 in apple processing wastes; however, nitrogen has to be added to avoid bulking of the activated sludge. Nitrogen is usually added as anhydrous ammonia or ammonium sulfate in amounts sufficient to obtain a carbon: nitrogen ratio of 30:1 in the waste stream.

For treating potato processing wastes, a mixed liquor system is satisfactory, affording BOD_5 removals as high as 95 percent. Contact stabilization, removed only about 80 percent of BOD_5 and a modification may not be considered satisfactory unless the processor reduces the waste loadings by in-plant modifications.

When settled sludge was reaerated, 90-95 percent BOD_5 removal was obtained as long as the BOD_5 loading was less than 50 to 70 kg(lb) BOD_5 per day per 100 kg(lb) of sludge solids. This rate decreased to less than 70 percent BOD_5 removal when the loading rate approached 200 kg(lb) per day per 100 kg(lb) of sludge solids. The sludge formed at these higher rates was less stable and bulking became a problem.

The treatment of citrus wastes using a step aeration type system, obtained up to 97 percent BOD_5 removal (averaging 90 percent removal) at loadings of 2.6-4.2 kg of BOD_5 per cubic meter per day (0.16 to 0.26 lbs of BOD_5 per cubic foot per day). No addition of nitrogen was necessary at these loading rates. Higher loading rates were followed by bulking primarily caused by *Sphaerotilus*. Temperatures above 36°C were detrimental and at 43°C were lethal to the system. Conventional activated sludge methods for the treatment of citrus wastes, 30-50 mg/l nitrogen and 5-10 mg/l phosphorus had to be added to obtain higher rates of BOD_5 removal and sludge with good settling characteristics.

The extended aeration modification of the activated sludge process is similar to the conventional activated sludge process, except that the mixture of activated sludge and raw materials is maintained in the aeration chamber for longer periods of time. The common detention time in extended aeration is one to three days, rather than six hours. During this prolonged contact between the sludge and raw waste, there is ample time for organic matter to be adsorbed by the sludge and also for the organisms to metabolize the removal of organic matter which has been built up into the protoplasm of the organism. Hence, in addition to high organic removals from the waste waters, up to 75 percent of the organic matter of the microorganisms is decomposed into stable products and consequently less sludge will have to be handled.

In extended aeration, as in the conventional activated sludge process, it is necessary to have a final sedimentation tank. Some of the solids resulting from extended aeration are rather finely divided and therefore settle slowly, requiring a longer period of settling.

The long detention time in the extended aeration tank makes it possible for nitrification to occur. If it is desirable for this to occur, it is necessary to have sludge detention times in excess of three days. This can be accomplished by regulating the amounts of sludge recycled and wasted each day. Oxygen enriched gas could be used in place of air in the aeration tanks to improve overall performance. This would require that the aeration tank be partitioned and covered, and that the air compressor and dispersion system be replaced by a rotating sparger system, which costs less to buy and operate. When co-current, staged flow and recirculation of gas back through the liquor is employed, between 90 and 95 percent oxygen utilization is claimed. Although this modification of activated sludge has not been used in treating apple, citrus or potato processing wastes, it is being used successfully for treating other organic wastes

Activated sludge in its varied forms is an attractive alternative in cannery waste treatment. Conventional design criteria is not directly transferrable from municipal applications. However, high levels of efficiency are possible at the design loadings normally employed in treating other types of high strength organic wastes. The general experience has been that biological solids separation problems can be avoided: if the dissolved oxygen concentration remains above zero throughout the aeration basin, if management minimizes very strong, concentrated waste releases, and if sufficient amounts of nitrogen are available to maintain a critical nitrogen: BOD5 ratio. This ratio has been recommended to be 3 to 4 kg(lb) N per 100 kg(lb) of BOD5 removed. Numerous cases have been reported of successful combined treatment of cannery and domestic wastes by activated sludge and its modifications. Activated sludge systems require less room than other high reduction biological systems, but have higher equipment and operating costs. Properly designed and operated systems can treat cannery wastes to achieve high BOD reductions.

Biological Filtration (Trickling Filter)

The trickling filter process has found application in treatment of food processing wastes. Very tall filters employing synthetic media, high recirculation, and forced air circulation have been used to treat strong wastes in the 300-4000 mg/l BOD5 range.

The purpose of the biofilter system is to change soluble organic wastes into insoluble organic matter primarily in the form of bacteria and other higher organisms. As the filter operates, portions of the biological growth slough off and are discharged as humus with the filter effluent. Usually, some physical removal system is required to separate this insoluble organic material which can be treated by other suitable methods, usually anaerobic fermentation in a sludge digestor.

Trickling filters are usually constructed as circular beds of varying depths containing crushed stone, slag, or similar hard insoluble materials. Liquid wastes are distributed over this bed at a constant rate and allowed to "trickle" over the filter stones. Heavy biological growths develop on the surface of the filter "media" throughout the depth of the filter and, also, within the interstitial spaces.

The biological film contains bacteria; (Zooglea, Sphaerotilus, and Beggiatoa); fungi (Fusarium, Geotrichum, Sepedonium); algae, both green and blue-green (Phormidium, Ulothrix, Mononostrona); and a very rich fauna of protozoa. A grazing fauna is, also, present on these beds consisting of both larval and adult forms of worms (Oligochaeta), insects (Diptera and Coleoptera, among others), and spiders and mites (Arachnida).

A common problem with this type of filter is the presence of flies which can become a severe nuisance. Insect prevention can usually be prevented by chlorinating the influent or by periodically flooding the filter.

Recirculation of waste water flows through biological treatment units are often used to distribute the load of impurities imposed on the unit and smooth out the applied flow rates. Trickling filter BOD_5 removal efficiency is affected by temperature and the recirculation rate. Trickling filters perform better in warmer weather than in colder weather. Recirculation of effluent increases BOD_5 removal efficiency as well as keeping reaction type rotary distributers moving, the filter media moist, organic loadings relatively constant, and increases contact time with the biologic mass growing on the filter media.

Furthermore, recirculation improves distribution, equalizes unloading, obstructs entry and egress of filter flies, freshens incoming and applied waste waters, reduces the chilling of filters, and reduces the variation in time of passage through the secondary settling tank.

Trickling filter BOD_5 removal efficiency is inversely proportional to the BOD_5 surface loading rate; that is, the lower the BOD_5 applied per surface area, the higher the removal efficient. Approximately 10-90 percent BOD reduction can be attained with trickling filters.

Anaerobic Processes

Elevated temperatures (29° to 35°C or 85° to 95°F) and the high concentrations typically found in apple, citrus or potato wastes make these wastes well suited to anaerobic treatment. Anaerobic or faculative microorganisms, which function in the absence of dissolved oxygen, break down the organic wastes to intermediates, such as organic acids and alcohols. Methane bacteria then convert the intermediates primarily to carbon dioxide and methane. Also, if sulfur compounds are present, hydrogen sulfide may be generated. Anaerobic processes are economical because they provide high overall removal of BOD5 and suspended solids with no power cost (other than pumping) and with low land requirements. Two types of anaerobic processes are possible: anaerobic lagoons and anaerobic contact systems.

Anaerobic lagoons are used in the industry as the first step in secondary treatment or as pretreatment prior to discharge to a municipal system. Reductions of 85 percent in BOD5 and 85 percent in suspended solids can be achieved with these lagoons. A usual arrangement is two anaerobic lagoons relatively deep (3 to 5 meters, or about 10 to 17 feet), low surface-area systems with typical waste loadings of 240 to 320 kg BOD5/1000 cubic meters (15 to 20 lb BOD5/1000 cubic feet) and a detention time of several days.

Plastic covers of nylon-reinforced Hypalon, polyvinyl chloride, and styrofoam can be used on occasion to retard heat loss, to ensure anaerobic conditions, and hopefully to retain obnoxious odors. Properly installed covers provide a convenient method for collection of methane gas.

Influent waste water flow should be near, but not on, the bottom of the lagoon. In some installations, sludge is recycled to ensure adequate anaerobic seed for the influent. The effluent from the lagoon should be located to prevent short-circuiting the flow and carry-over of the scum layer.

Advantages of an anaerobic lagoon system are: initial low cost, ease of operation, and the ability to handle shock waste loads, and, yet, continue to provide a consistent quality effluent. The disadvantage of an anaerobic lagoon is odor although odors are not usually a serious problem at well managed lagoons.

Anaerobic lagoons used as the first stage in secondary treatment are usually followed by aerobic lagoons. Placing a small, mechanically aerated lagoon between the anaerobic and aerobic lagoons is becoming popular. It is currently popular to install extended aeration units following the anaerobic lagoons to obtain nitrification.

The anaerobic contact system requires far more equipment for operation than do anaerobic lagoons, and consequently, is not as commonly used. The equipment consists of: equalization tanks, digesters with mixing equipment, air or vacuum gas stripping units, and sedimentation tanks (clarifiers). Overall reduction of 90 to 97 percent in BOD and suspended solids is achievable.

Equalized waste water flow is introduced into a mixed digester where anaerobic decomposition takes place at a temperature of about 33° to 35°C (90° to 95°F). BOD_5 loadings into the digester are between 2.4 and 3.2 kg/cubic meter (0.15 and 0.20 lb/cubic foot), and the detention time is between three and twelve hours. After gas stripping, the digester effluent is clarified and sludge is recycled at a rate of about one-third the raw waste influent rate. Sludge at the rate of about 2 percent of the raw waste volume is removed from the system.

Advantages of the anaerobic contact system are high organic waste load reduction in a relatively short time; production and collection of methane gas that can be used to maintain a high temperature in the digester and also to provide auxilary heat and power; good effluent stability to waste load shocks; and application in areas where anaerobic lagoons cannot be used because of odor or soil conditions. Disadvantages of anaerobic contractors are high initial and maintenance costs and some odors omitted from the clarifiers.

Anaerobic contact systems are usually used as the first stage of secondary treatment and can be followed by the same systems that follow anaerobic lagoons or trickling filter roughing systems.

Other Aerobic Processes

Aerated lagoons have been used successfully for many years in a number of installations for treating apple, citrus, or potato wastes. However, with recent tightening of effluent limitations and because of the additional treatment aerated lagoons can provide, the number of installations is increasing.

Aerated lagoons use either fixed mechanical turbine-type aerators, floating propeller-type aerators, or a diffused air system for supplying oxygen to the waste water. The lagoons usually are 2.4 to 4.6 m (8 to 15 feet) deep, and have a detention time of two to ten days. BOD_5 reductions range from 40 to 60 percent with little or no reduction in suspended solids. Because of this, aerated lagoons approach conditions similar to extended aeration without sludge recycle.

Advantages of this system are that it can rapidly add dissolved oxygen (DO) to convert anaerobic waste waters to an aerobic state; provide additional BOD_5 reduction; and require a relatively small amount of land. Disadvantages are the power requirements and that the aerated lagoon, in itself, usually does not reduce BOD_5 and suspended solids adequately to be used as the final stage in a high performance secondary system. Aerated lagoons are usually a single stage of secondary treatment and should be followed by an aerobic (shallow) lagoon to capture suspended solids and to provide additional treatment.

Aerobic lagoons (or stabilization lagoons or oxidation ponds), are large surface area, shallow lagoons, usually 1 to 2.3 m deep (3 to 8 feet), loaded at a BOD_5 rate of 22-56 kilograms per hectare (20 to 50 pounds per acre). Detention times will vary from several days to six or seven months; thus, aerobic lagoons require large areas of land.

Aerobic lagoons serve three main functions in waste reduction:

1. Allow solids to settle out.

2. Equalize and control flow.

3. Permit stabilization of organic matter by aerobic and facultative microorganisms and also by algae.

Actually, if the pond is quite deep, 1.8 to 2.4 m (6 to 8 feet), so that the waste water near the bottom is void of dissolved oxygen, anaerobic organisms may be present. Therefore, settled solids can be decomposed into inert and soluble organic matter by aerobic, anaerobic or facultative organisms, depending upon the lagoon conditions. The soluble organic matter is, also, decomposed by microorganisms causing the most complete oxidation. Wind action assists in carrying the upper layer of liquid (aerated by air-water interface and photosynthesis) down into the deeper portions. The anaerobic decomposition generally occurring in the bottom converts solids to liquid organics which can become nutrients for the aerobic organisms in the upper zone.

Algae growth is common in aerobic lagoons; this currently is a drawback when aerobic lagoons are used for final treatment. Algae may escape into the receiving waters, and algae added to receiving waters are considered a pollutant. Algae in the lagoon, however, play an important role in stabilization. They use CO2, sulfates, nitrates, phosphates, water and sunlight to synthesize their own organic cellular matter and give off free oxygen. The oxygen may then be used by other microorganisms for their metabolic processes. However, when algae die they release their organic matter in the lagoon, causing a secondary loading. Ammonia disappears without the appearance of an equivalent amount of nitrite and nitrate in aerobic lagoons. From this, and the fact that aerobic lagoons tend to become anaerobic near the bottom, it appears that some denitrification is occurring.

High winds can develop a strong wave action that can damage dikes; Riprap, segmented lagoons, and finger dikes are used to prevent wave damage. Finger dikes, when arranged appropriately, also prevent short circuiting of the waste water through the lagoon. Rodent and weed control, and dike maintenance are all essential for good operation of the lagoons.

Advantages of aerobic lagoons are that they reduce suspended solids, oxidize organic matter, permit flow control and waste water storage.

Disadvantages are the large land required, the algae growth problem, and odor problems.

Aerobic lagoons usually are the last stage in secondary treatment and frequently follow anaerobic or aerated lagoons. Large aerobic lagoons allow plants to store waste water discharges during periods of high flow in the receiving body of water or to store for irrigation during the summer. These lagoons are particularly popular in rural areas where land is available and relatively inexpensive.

Rotating Biological Contactor

The rotating biological contractor (RBC) consists of a series of closely spaced flat parallel disks which are rotated while partially immersed in the waste waters being treated. A biological growth covering the surface of the disk adsorbs dissolved organic matter present in the waste water. As the biomass on the disk builds up, excess slime is sloughed off periodically and is removed in sedimentation tanks. The rotation of the disk carries a thin film of waste water into the air where it absorbs the oxygen necessary for the aerobic biological activity of the biomass. The disk rotation, also, promotes thorough mixing and contact between the biomass and the waste waters. In many ways the RBC system is a compact version of a trickling filter. In the trickling filter the waste waters flow over the media and, thus, over the microbial flora; in the RBC system, the flora is passed through the waste water.

The system can be staged to enhance overall waste water reduction. Organisms on the disks selectively develop in each stage and are, thus, particularly adapted to the composition of the waste in that stage. The first couple of stages might be used for removal of dissolved organic matter, while the latter stages might be adapted to other constituents, such as nutrient removal.

The major advantages of the RBC system are: its relatively low installed cost, the effect of staging to obtain dissolved organic matter reductions, and its good resistance to hydraulic shock loads. Disadvantages are: that the system should be housed to maintain high removal efficiencies and to control odors. Although, this system has demonstrated its durability and reliability when used on domestic wastes, it has not yet been fully tested to treat apple, citrus, or potato processing wastes.

Rotating biological contactors could be used for the entire aerobic secondary system. The number of stages required depends on the desired degree of treatment and the influent strength. Typical applications of the rotating biological contactor, however, may be for polishing the effluent from anaerobic processes and from roughing trickling filters and as pretreatment prior to discharging wastes to a municipal system.

A BOD5 reduction of over 90 percent is achievable with a multi-stage RBC.

PERFORMANCE OF VARIOUS SECONDARY TREATMENT SYSTEMS

Table 25 shows BOD5 and SS removal efficiencies for various secondary biological treatment systems used to treat wastes from apple (AP), citrus (CI) and potato (PO) processing systems. These systems are all in operation and many show high degrees of BOD5 and SS reduction. Three other multiple aerated lagoon systems are, also, operating but are not included because raw waste data is not available. Some of the systems process wastes from each subcategory within a commodity and therefore treatment effectiveness is applicable to each commodity subcategory. The range in processing plant capacity for the systems listed varies from less than 453.5 kkg/D (500 T/D) to 5,442 kkg/D (6,000 T/D).

The most commonly used treatment systems are multiple aerated lagoons and activated sludge. Each system has been used to treat waste water from the processing of apples, citrus, and potatoes.

Table 25 lists three apple plants utilizing three different treatment systems, each of which has at least 95 percent BOD5 removal. There are four citrus plants utilizing four different treatment systems, each of which has at least 95 percent BOD5 removal. There are three potato plants utilizing three different treatment systems, each of which has at least 95 percent BOD5 removal.

Reliability, operability and consistency of operation of the waste water treatment processes found to be most frequently used in the fruit and vegetable industry can be high if appropriate designs and operational techniques are employed. The end-of-pipe treatment utilizing biological systems is a well established technology that requires attention to a limited number of variables to insure a high degree of reliability.

The most important operational aspects of these biological systems are equipment reliability and attention to operating detail and maintenance. Spare aeration equipment (usually floating surface aerators) improves the possibility of consistent operation;however, many treatment systems have an adequate overcapacity already installed as insurance against the results of equipment failure. It is desirable to install spare equipment at critical points, for example, sludge return pumps. Perhaps of equal importance is a design that permits rapid and easy maintenance of malfunctioning equipment.

Therefore, control of the biological treatment plant and the consistency of the results obtained are largely a matter of conscientious adherence to well-known operational and maintenance procedures. Automatic control of biological treatment plants is far from a practical point. Although in-line instrumentation for measurement of pH, dissolved oxygen, temperature, turbidity and so on, can improve the effectiveness of operation, its use is minimal in the industry's existing waste water treatment plants. Nevertheless, no practical in-line instrumentation can replace the judicious attention to operational details of a conscientious crew of operators.

An activated sludge system which is permitted to operate at a constant F:M ratio all year round and with minimum operational changes would have a natural variation as shown in Section IX by the solid line in Figure 10. A similar system with careful operational control would have a controlled monthly average variation as shown by the points. Although the mean value is the same, the amount of natural variation is controlled by the operator through aeration rate control, sludge recycling and F:M ratio adjustments. These adjustments can be made daily so that monthly averages can be held within the desired limits.

Although, a well-operated and properly designed facility can be controlled within ±25 percent of the average on a monthly operating basis. A system with minimal operational control or an allowance of ±50 percent of the averages on a monthly basis has been used to calculate the maximum monthly effluent limitation.

Data from a well operated and properly designed activated sludge system at PO-128 demonstrates that a 50 percent allowance is justified. The annual average BOD_5 and TSS are 0.7 kg/kkg (1.4 lb/ton) and 0.9 kg/kkg (1.8 lb/ton) respectively; the maximum monthly BOD_5 and TSS discharges are 1.04 kg/kkg (2.08 lb/ton) and 1.32 kg/kkg (2.63 lb/ton) respectively. Thus, the maximum montly discharges are less than the averages on a monthly basis plus 50 percent.

TABLE 25

EFFECTIVENESS OF VARIOUS SECONDARY BIOLOGICAL TREATMENT SYSTEMS

SECONDARY TREATMENT SYSTEM	BOD5 REDUCTTON PERCENT	SS REDUCTION PERCENT
MULTIPLE AERATED LAGOONS		--
AP 121	98	--
CI 105 & 109	98	--
CI 106	89	79
CI 118	87	--
PO 110	98	--
ACTIVATED SLUDGE		
AP 140	99	35
CI 123	97	56
PO 101	73	28
PO 107	71	29
PO 128	94	94
ANAEROBIC & AEROBIC LAGOONS		
CI 108	99	12
PO 109	95	93
TRICKLING FILTERS		
PO 127	85	92
TRICKLING FILTER & AERATED LAGOONS		
AP 103	96	87
CI 127	98	80
ACTIVATED SLUDGE & AERATED LAGOONS		
CI 119	88	--
PO 128	98	95

ADVANCED TREATMENT SYSTEMS

A discussion of advanced treatment methods is presented in this section. For the most part, these methods are applicable to the treatment of the waste streams after secondary treatment involving the use of some combination of biological treatment for reduction of BOD_5 and of settling ponds or equipment for reduction of suspended solids.

Many of the technologies discussed do not, in themselves, constitute a complete treatment process, but would become part of a complete process.

In evaluating the treatment methods applicable to effluents from secondary treatment operations, it is assumed that all particulate solids greater than 20 microns have been removed from the waste effluent stream.

Carbon Adsorption

The reduction of tastes and odors in water supplies by adsorption of the offending substances on activated carbon is probably the most important direct use of adsorption technology in water treatment. Columns or beds of granular activated carbon are employed: (1) for concentrating organic pollutants from water for purposes of analysis or, (2) for removal of the pollutants. Some of the removal of color-producing substances and other pollutants from water during coagulation may also be the result of adsorption.

The fixed bed or countercurrent operation is the most effective and efficient way of using the activated carbon. The influent comes in contact with the adsorbent along a gradient of mounting residual activity until the most active carbon gives a final polish to the effluent stream.

Partial regeneration of carbon by thermal volatilization or steam distillation of organic adsorbates is possible, but available regeneration procedures will have to be improved or new ones invented if adsorption is to become a widely useful operation in water treatment. The use of multi-hearth furnaces such as used in the sugar refineries is a possibility. Difficulties and costs of regeneration explain why powdered activated carbon continues to be widely used.

Granular activated carbon can replace other filtering materials in structures not unlike present-day rapid filters. Beds of granular activated carbon can, in fact, be made to perform as both filters and adsorbents. However, activated carbon filters must be somewhat deeper than sand filters, even though they may be operated at somewhat higher rates of flow per cubic meter (square foot) of bed. For adsorption, the rate of flow per cubic meter (cubic foot) rather than per square meter (square foot) of bed is, understandably, the important parameter in practice.

Distillation

This unit process has received wide attention as a method of removing water from saline solutions where fresh water is in short supply. It differs from most other waste treatment processes in that the recovered water is pure and may be recycled indefinitely. Little work, if any, has been done so far in transferring this new technology to fruit and vegetable processing wastes.

It is not likely to be used in waste treatment, because the process either uses a lot of fuel (as in a single step flash) or has a high capital cost (as in a multiple flash) or a combination of both.

Electrodialysis

Water can be desalinized electrochemically by electrodialysis through membranes selectively permeable to cations or anions. Dialysis is the fractionation of solutes made possible by differences in the rate of diffusion of specific solutes through porous membranes. Semipermeable membranes are thin barriers that offer easy passage to some constituents. High selective membranes have been prepared by casting ion-exchange resins as thin films. Dialytic processes are common separation techniques in laboratory and industry. The recovery of caustic soda from industrial wastes, such as viscose press liquor from the rayon industry and mercerizing solutions, is an example of continuous-flow dialysis.

Electrodialysis is only applicable to saline solutions of which are readily ionized and is not applicable to the separation unionizable soluble organics that exist in effluents from biological treatment systems.

Eutectic Freezing

Eutectic freezing operates at the eutectic temperature of the incoming water. Down to the eutectic point, only ice is formed. At the eutectic point, ice crystals nucleate and grow independently of salt crystals and other substances in the water. Further removal of heat does not continue to lower the temperature. Both ice and sludge freeze, and they can then be separated because the ice floats and the frozen sludge sinks.

The freezing breaks down the sludge and destroys its waterbinding capacity which, in turn, permits better sludge dewatering. Both functions, the removal of water in the form of ice crystals and the concentration of sludge by freezing have been demonstrated in a laboratory scale only as water-inorganic salt systems.

Filtration

Two types of filtration will be considered in this discussion: (1) sand (slow and rapid) and (2) diatomaceous earth. A slow sand filter is a specially prepared bed of sand or other mineral fines on which doses of waste water are intermittently applied and from which effluent is removed by an under-drainage system. The solids removal occurs mainly at the surface of the filter. BOD removal occurs primarily as a function of the degree of solids removal although some biological action occurs in the top inch or two of sand. Effluent from the sand filter is of a high quality with BOD and suspended solids concentrations very low.

Slow sand filters require larger land areas than rapid filter facilities on the order of five times (or more) as much land; however, slow sand filters may operate up to 60 days without cleaning, whereas rapid sand filters are usually cleaned by backwashing every 24 hours.

Slow sand filters require no extra preparatory water treatment prior to filtration, although it is recommended, whereas, rapid sand filters are designed to remove the remainder of solids after treatment by coagulation, flocculation and sedimentation. Construction costs of slow sand filters are relatively high due to the large area requirements; however, operating and maintenance costs are relatively low since slow sand filters may operate for long durations. Rapid sand filters have a relatively low construction cost due to their low area requirements; however, operating and maintenance costs are relatively high since they cannot operate for long periods of time without backwashing. Food processing wastes are likely to cause clogging of the filters after only a short period of operation unless adequate treatment precedes them.

Rapid filters are subject to a variety of ailments, such as: cracking of the bed, formation of mud balls, plugging of portions of the bed, jet actions at the gravel-sand separation plane, sand bails, and sand leakage into the under-drain systems. Usually these problems can be minimized or eliminated by proper design and plant operation. Sand filters are well noted for their efficient removal of bacteria, color, turbidity, iron and large microorganisms.

Diatomaceous earth filters have found use as: (1) mobile units for water purification in the field and (2) stationary units for swimming pools and general water supplies. The filter medium is a layer of diatomaceous earth built up on a porous septum. The resulting pre-coat is supported by the septum, which serves also as a drainage system. Water is strained through the pre-coat unless the applied water contains so much turbidity that the unit will maintain itself only if additional diatomaceous earth, called body feed, is introduced into the incoming water and preserves the open texture of the layer.

Skeletons of diatoms 0.5 to 12 units in size compose the diatomaceous earth mined from deposits. Pre-coating requires 0.49 to 2.44 kg (0.1 to

0.5 lb) of diatomaceous earth per sq m (sq ft) of filter area. Body feed is added in a ratio close to 1.25:1 on a dry basis when waters contain inorganic silts. For organic slimes the ratio is stepped up to about 3:1. The filter operates at rates of 0.8 to 2.11 liters per minute per sq m (2.5 to 6 gpm per sq ft). Backwashing rates of 2.46 to 3.51 liters per minute per sq m (7 to 10 gpm per sq ft) remove spent filter cake.

There are few known applications as yet on food processing wastes.

Flotation

Flotation has previously been described as a part of the Preliminary Treatment System. It has been primarily designed for the removal of floatables from a waste effluent stream. As a tertiary treatment step, it would not be required if it had been used in the preliminary treatment system. Otherwise, it may be desirable to use this type of design either in the tertiary treatment or in-plant water reuse system.

Foam Separation

Many contaminants in waste water possess surface-active properties which will produce a foam upon agitation or aeration. The process of foam separation takes advangage of this property in order to remove these constituents in a concentrated form. This is true for many food processing waste effluents.

Surface-active material will concentrate at a gas-liquid interface and form a foam. This foam is formed by the attraction of the hydrophobic end of a molecule to the gas phase, while the hydrophilic end of the molecule carries water in the liquid phase. As the foam is generated and rises, suspended solids and other materials are removed by entrainment.

The process of foam separation has been experimentally applied to the removal of surface-active materials, such as ABS, from waste solutions and has, also, been used to remove trace contaminants by combining them with an added foaming agent.

Foam separation must be considered experimental when applied to food processing waste effluents. At the present time, there are no known installations in the food processing industry utilizing foam separation technology for cleanup of the waste effluent streams.

Freezing

Freezing must be differentiated from eutectic freezing in that this system is used only to freeze the concentrated waste effluent stream to permit a more efficient dewatering of the sludge solids. This technology is not presently being applied to the treatment of food processing wastes.

Ion Exchange

Ion exchange can be used for the removal of undesirable anions and cations from a waste water. Cations are exchanges for hydrogen or sodium, and anion for hydroxyl ions.

Examples are: (1) the exchange of calcium and magnesium ions for sodium ions by passage of water through a bed of sodium zeolite which is regenerated by brine (base or cation exchange); (2) the exchange of sodium and potassium ions as well as calcium and magnesium ions by synthetic organic cation exchangers, the cation exchanger being regenerated with acid and the anion exchanger with sodium carbonate. The precipitation of iron and manganese on manganese zeolite and the regeneration of the zeolite with potassium permanganate are, in a sense, examples of surface or contact precipitation rather than ion exchange. Byproducts are spent washes.

The performance and economics of ion exchange are related to the capacity of the resin to exchange ions and to the quantity of regenerant required. Since exchange occurs on an equivalent basis, the capacity of the bed is usually expressed as equivalent per liter of bed volume.

The treatment of waste water by ion exchange involves a sequence of operating steps. The waste water is passed through the resin until the available exchange sites are filled and the contaminant appears in the effluent. This process is defined as the breakthrough. At this point, treatment is stopped and the bed is backwashed to remove dirt and to regrade the resin. The bed is then ready for another treatment cycle.

The normal method of water deionization has been to make the first pass through a strong acid column, cation exchange resin. Effluent from the first column goes to a second column of anion exchange resin to remove the acid formed in the first step. A great variety of ion exchange resins have been developed over the years for specific deionization objectives for various water quality conditions.

Wastewater treatment with ion exchange resins has been investigated and attempted over 40 years; however, recent process developments in the treatment of secondary effluent have been particularly successful in achieving high quality effluent at reasonable capital and operation costs. One such process is a modification of the Rohm and Haas, Desal process. In this process a weak base ion exchange resin is changed to the bicarbonate form and the secondary effluent is treated by the resin to convert the inorganic salts. Next, the process includes a flocculation/aeration and precipitation step to remove organic matter; however, this should not be necessary if the sand filter and/or carbon adsorption system is used upstream of the ion exchange system. The effluent from the first ion exchange column is further treated by a weak cation resin to reduce the final dissolved salt content to approximately five mg/l. The anion resin in this process is regenerated with aqueous ammonium and the cation resin with an aqueous sulfuric acid. The resins did not appear to be susceptible to fouling by the organic constituents of the secondary effluent used in this experiment.

Other types of resins can be used for nitrate and phosphate removal, as well as color bodies, COD, and fine suspended matter. Removal of these various constituents can range from 75 to 97 percent, depending on the constituent.

The cycle time on the ion exchange unit will be a function of the time required to block or to take up the ion exchange sites available in the resin contained in the system. Blockage occurs when the resin is fouled by suspended matter and other contaminants. The ion exchange system is ideally located at the end of the waste water processing scheme, thus having the highest quality effluent available as a feed water.

The organic nature of most food processing waste effluents is not conducive to the employment of ion exchange technology as a method of treating waste effluent. Ion exchange has found its greatest acceptance in the treatment of inorganic contaminants and in public waterworks.

Microscreening

Microscreening has been a viable solids-removal process for twenty years. A microscreen consists of a rotating drum with a screen or fabric constituting the periphery. Feedwater enters the drum internally and passes radially through the screen with the concomitant deposition of solids on the inner surface of the screen. At the top of the drum pressure, jets of water are directed onto the screen to remove deposited solids. This backwash stream of dislodged solids and washwater is captured in a receiving hopper inside the drum and flows out through the hollow axle of the unit. In order to reduce slime growths on the screen, an ultraviolet lamp is continually operated in close proximity to the screen. The driving force for the system is the head differential between the inside and outside of the screen. As solids are removed on the screen a mat is formed which improves the solids removal efficiency and also results in increased head loss through the screen. The maximum head loss is usually limited to 0.15 meters (6 inches) in order to prevent screen damage. In order to prevent the limiting head loss from being exceeded, drum speed and wash water pressure are increased. In newer units automatic controls handle these adjustments.

One type of microscreen displayed efficiencies in removal of solids from 55 to 73 percent, while another type showed 57 to 89 percent efficiencies in tabulation of average removals. Due to differences in feed character and operational techniques, the data could not be compared. Individual studies demonstrated the effects of a number of design, maintenance and operational factors on the performance of the unit:

Design

1. Approximately one-half of the wash water applied to the screen actually penetrates and is removed as the waste stream with dislodged solids.

2. The waste stream is usually returned to the end of the main plant.

3. It is desirable to have gravity flow from the clarifier to the microscreener to avoid shearing of the more fragile solids.

4. Total head loss through the system is only 0.30 to 0.46 meters (12 to 18 inches).

5. Prechlorination should be avoided in order to protect the screen.

6. Chloride concentrations exceeding 500 mg/l (0.0021 lb/gal) may cause corrosion problems.

7. Microscreens do not successfully remove floc particles resulting from coagulation by chemicals such as aluminum sulfate.

Maintenance

1. Screens for the pressure washing system tend to clog, mainly due to grease in the effluent.

2. Most units will require frequent (approximately once a week) cleaning with a hypochlorite solution which entails a few hours of removal from service in order to clean the fabric.

3. High iron or manganese concentrations in the feed may necessitate an occasional acid wash of the screen to destroy the resulting film buildup.

Operation

1. Minimum drum speeds consistent with head loss limitations will give the greatest removal of suspended solids.

2. Higher pressures for the jet washing system are more beneficial than greater quantities of water.

3. High solids loadings can cause severe reductions (up to two-thirds design capacity) in throughput as well as acceleration of slime buildup.

Nitrification-Denitrification

Nitrification-denitrification is a two-step process used to remove nitrogen from treated waste waters.

In the first step, after most of the carbonaceous materials has been removed from the waste water, ammonia nitrification occurs in an aerated system with the subsequent production of nitrites and nitrates.

The next step, denitrification, occurs in the absence of oxygen and is responsible for converting nitrates to nitrogen and nitrogen oxides. The reaction rate is increased by adding a biodegradable carbon source, such as methanol. The wastewater from the second step is then transferred to another aeration pond where the nitrogen and nitrogen oxide gases are removed.

Over the range of operating temperatures, denitrification can maintain a 90 percent removal of total nitrogen. The optimum efficiency temperature was found to be 30°C for most aerobic waste systems, with efficiency drops at both higher and lower temperatures.

The system has been demonstrated on a pilot plant scale, but it is premature to draw conclusions as to the effectiveness and reliability of the nitrification-denitrification process in a full-scale operation.

Ozonation

If ozone is to be employed effectively and efficiently as a deodorant, decolorant and disinfectant of drinking water, its physical and chemical properties in water solution and their influence on pathogenic microorganisms need to be known over the full range of possible exposures.

Only in the absence of organic matter does ozone follow the laws of ideal, i.e., nonreacting, gases in water. The distribution coefficient of ozone between air and water, i.e., the ratio of the equilibrium concentration of ozone in the liquid phase to that in the gas phase at like temperature and pressure, is then about 0.6 at 0°C and 0.2 at 20°C.

Increasing either the total pressure of the system or the partial pressure of ozone in the air raises the concentration of ozone in water in direct proportion of these pressures. In the presence of oxidizable substances, their nature and concentration in water rather than the distribution coefficient govern the amount of entering ozone.

As a disinfectant, ozone is said to possess an all-or-none property, implying that it produces essentially no disinfection below a critical concentration but substantially completes disinfection above that concentration.

Because the absorption of ozone from the air into the water to be disinfected is a matter of contact opportunity, contactcamber design aims at a maximization of (1) effective interface, (2) driving force or concentration of differential, and (3) time of exposure with due consideration of advantages to be gained by countercurrent operation.

As a rule, capital and running cost of ozonation equipment cannot compete with those of comparable chlorination equipment for the treatment of a given water unless ozone is called upon and able to remove objectionable odors and tastes and reduce the color of the water more effectively than chlorine in combination with activated carbon and coagulants. Ozone, also, leaves no residual, thereby becoming unable to safeguard the treated water from future pathogenic contamination.

Reverse Osmosis

Osmotic pressure drives water molecules through a permeable membrane from a dilute to a concentrated solution in search of equilibrium. This natural response can be reversed by placing the salt water under hydrostatic pressures higher than the osmotic pressure.

A good deal of experimentation has been carried out in an attempt to apply membrane processes including reverse osmosis, ultrafiltration and electrodialysis to the treatment of industrial wastes. Reverse osmosis has the capability of removing dissolved and suspended materials of both organic and inorganic nature from waste streams. However, organic-laden streams tend to foul reverse osmosis membranes resulting in substantially decreased throughput.

At present, none of these membrane processes appear to have direct application to the treatment of the food processing wastes under consideration here. These processes are relatively expensive when applied to the large volumes of waste generated and the heavy solids concentrations in food processing waste water. A primary problem is that the rate of pure water production in reverse osmosis has been low, and, thus, has not been economically acceptable.

Recent developments of the spiral or hollow tube reverse osmosis systems permit large membrane areas to be incorporated into a small space, thus permitting large volumes of water to be treated. The use of either the spiral or hollow tube system requires that all particles larger than 10 to 20 microns be removed from the waste stream before entering the reverse osmosis system.

Another problem with this system is the bacterial growth on or near the membrane and its damaging effect on the membrane.

Because chlorine damages the membranes presently available, the chlorination of the water cannot occur before the reverse osmosis step.

Reverse osmosis units are, also, sensitive to both alkaline and high temperature fluids. It is desirable to avoid both conditions if reverse osmosis is to be used.

Solvent Extraction

This widely used process could theoretically be employed to extract soluble organics from treatment wastes by employing a selective solvent. Since the solvents, themselves, are likely to have solubilities in water comparable to the concentration of the organics present, it is unlikely that this process would have utility in food processing.

Ultrafiltration

Ultrafiltration uses a membrane process similar to reverse osmosis for the removal of contaminants from water. Unlike reverse osmosis, ultrafiltration is not impeded by osmotic pressure and can be effected at low pressure differences of 1.3-7.8 atmospheres (5-100 psi). The molecular weight range of materials that might be removed by ultrafiltration is from 500 to 500,000. This would remove such materials as some microorganisms, starches, gums, proteins and clays. Ultrafiltration is finding applications in the food industry in sugar purification, whey desalting, and fractionation. It can be used as a substitute for thickeners, clarifiers and flocculation in waste water treatment. In addition to removal of the above contaminants from waste water, it can, also, be applied to sludge dewatering.

At the present time, because of high capital and operating costs, this system has not found acceptance in the treatment of waste effluents.

ULTIMATE DISPOSAL METHODS

Percolation and Evaporation Lagoons

The liquid portion of cannery wastes can be "completely" treated and discharged through percolation and evaporation lagoons. These ponds can be sized according to the annual flow, so that the inflow plus the incidentally added water are equal to the percolation and evaporation losses. There is, theoretically, no surface outflow in the usual sense. Percolation and evaporation lagoons are subject to many of the problems of ponds discussed previously.

The food processing and the biological solids grown in the pond are a major operating problem. The soil interstices will eventually become biologically sealed, causing percolation rates to be greatly diminished. Unless remedial action is taken, the pond becomes largely an evaporation lagoon. To prevent this, annual scarification and solids removal will generally be required.

There are two major objections to percolation-evaporation ponds. The first is that under almost any loading conditions the ponds may turn septic, with odor problems resulting. Secondly, there is the potential for long-range damage to aquifers, since objectionable and biologically resistant organics may be carried into the groundwater by continuous percolation.

Spray Irrigation

Spray irrigation is another method currently utilized by the food industry for disposal of its wastes. The design of such systems is rapidly becoming a highly scientific operation. Numerous cases of both unsatisfactory results and trouble-free experience have been encountered. Apparently such systems must be designed with a great deal of flexibility to handle unforeseen problems. The hydraulic and organic characteristics of the soil profile must be considered in the design as well as the rates of waste degradation. The need to properly balance nutrient loads to insure adequate microbiological activity and adequate growth of plants without undue losses of nutrients to ground waters must be considered. Other important design considerations include crop management insuring proper crops and corp sequences and climatic conditions considering evapotranspiration rates, precipitation and cold weather operation.

Currently, a study is being conducted by the USDA to evaluate the practice of land disposal of potato waste water. Several plants are involved including PO-102, PO-114, PO-115, PO-116, PO-121, PO-122 and PO-124. Their sizes range from 220 kkg/day (240 T/day) with water usages from 8760-15510 l/kkg (2100-3720 gal/T) and BOD from 8.6-31.95 kg/kkg (17.2-63.9 lb/T).

The application rates being studied range from approximately 95-168 kilograms organic matter per hectar per day (85 to 150 pounds organic matter per acre per day). Water applications will range from 9-37 thousand cubic meters per hectar per year (3 to 12 acre feet per acre per year) for existing disposal sites. Nitrogen in waste water may range from 50 to 125 ppm total N (much of it is organic), but through decomposition and mineralization, it should be converted to nitrate. The fields are planted with grass and other crops that can be harvested to remove some of the nitrogen, phosphorus and other plant nutrients. To remove the excess nitrogen above plant growth requirements, denitrification may be needed to minimize ground water pollution. Further study will be done in this area.

Spray irrigation consists essentially of spraying the liquid waste on a field at as high a rate and with as little accompanying nuisances or difficulties of operation as possible. Pretreatment of waste water to remove solids is suggested in order to prevent clogging of the spray nozzles. This preliminary treatment in preparation for spray irrigation has undoubtedly already reduced the BOD of the waste water.

Wastewater disseminated by spray irrigation percolates through the soil and the organic matter in the waste undergoes a biological degradation. The liquid in the waste stream is either stored in the soil or leached to a groundwater. Approximately 10 percent of the waste flow will be lost by evapotranspiration (the loss due to evaporation to the atmosphere through the leaves of plants).

Spray irrigation presents an ideal method for disposal of liquid cannery wastes when a combination of suitable features exists. These features include:

1. A large area of relatively flat land available at an economical price.

2. Proximity of the disposal area to the cannery.

3. Proper type of soil to promote optimum infiltration.

4. Absence of a groundwater underlying or nearby the disposal area which is being or could be used as a public water supply.

5. Absence of any suspended matter in the waste water of such a nature so as to cause clogging of the spray nozzles.

6. Maximum salt content in waste water of 0.15 percent.

7. Proper combination of climatic conditions conducive to cover crop growth, percolation and evaporation, i.e., sunny and relatively dry climate.

In actual practice, cannery wastes (after adequate screening) are usually retained in a "surge tank" of sufficient volume to provide continuous operation of sprays. The impounded screened waste is pumped to a header pipe and a series of lateral aluminum or lightweight lines under ample pressure to provide each sprinkler with similar volumes of waste for application to the land.

The amount of waste water reaching groundwater is variable quantity and rather difficult to predict. In some cases it might be expected that no usable groundwater would be involved. Considerable study seems to be needed in evaluating this potential problem.

The following factors must be evaluated in designing a land disposal system:

1. The site should be relatively level and well covered with vegetation. A sloping site may be considered for controlled runoff to a receiving water.

2. The soil should be light in texture and have a high sand or gravel content. Some organic matter may be beneficial, but high clay content is detrimental.

3. Spray testing and soil analyzing prior to full-scale irrigation is recommended.

4. Soil cultivation should be practiced to prevent compaction.

5. Groundwater levels at the spray site should be at least 10 feet below the surface to allow for proper decomposition of the waste as well as more rapid percolation.

With the proper equipment and controlled application of the waste, spray irrigation will completely prevent stream pollution, will not create odor problems, and is usually less expensive than other methods of waste disposal. The amount of land required may not, at present, be reliably predetermined. Since a cover crop will provide 85-90 percent more soil absorption, the type crop used is extremely important. A typical seed mixture for cover crop is:

Mammoth clover	19%
Ladino-Alsac Mixture	25%
Alta-fescue	25%
Redtop	18%
Orchard grass	13%

This mixture is sowed at the rate of 16 pounds per acre to produce as dense a cover crop as possible at the time of waste water application.

Different types of soils will give varying infiltration rates. It has been shown from soil descriptions the permeability of each soil layer has the following ranges of permeability.

Soil Type	Range of Coefficient of Permeability, K	
	m/min	ft/min
Trace fine sand	0.3 - 0.06	1.0 - 0.2
Trace silt	0.24 - 0.012	0.8 - 0.04
Little silt (coarse and fine)	0.0036 - 0.006	0.012 - 0.002
Some fine silt	0.00024 - 0.00012	0.0008 - 0.0004
Little Clayey silt		
Fissured clay-soils		
Organic soils		
Some clayey silt	0.00006 and lower	0.00002 and lower
Clay-soils dominating		

Thus, trace fine sand would be more suitable for spray or flood irrigation than clay soils because of higher rates of permeability. There are, of course, other factors which must be considered.

Many of the more recently constructed ultimate disposal systems consists of a combination of lagoons and land disposal. In this type of system large lagoons (ponds) having retention times of 30 days or more are constructed to receive the waste effluents. If odor becomes a problem because of location, then sufficient aeration equipment is provided to reduce or eliminate the odor. The waste effluent is removed from the pond or lagoon and directed to spray irrigation.

Soil fertility, crop production, and soil conservation considerations must, of necessity, be used as an ultimate basis for regulating land-spreading operations if the system is to remain continuously effective.

Wet Oxidation

The development and continuing perfection of oxidation methods for waste sludges and slurries that produce oxidized residues has been one of the major breakthroughs in waste treatment practice. Such residues are not putrescible and the processes produce little air pollution. The processes require thickening as pretreatment and greater concentrating. Furthermore, the process oxidation takes place in the presence of liquid water at 400-600°F and usually at high pressures of 18-103 atm (250-1,500 psi). The process may be operated on a continuous or batch basis and solids volume is greatly reduced and putrescibility nonexistent.

The current accepted practice in the food processing industry is to separate the solids from the waste effluent streams for use as cattle feed and in this manner receive some economic benefit. However, if a wet oxidation system for waste disposal of solids is used, then it would be desirable to leave as many of the organic solids in the effluent as possible. This waste effluent is oxidized and then separated into two waste effluent streams, one which is clean water (condensation) and the second high in oxidized solids. It is this reason that has restricted or prevented the application of this process to the food processing industry.

Wet oxidation reduces the COD by about 80 percent to less than 20 mg/l, and 90 percent of the volatile solids are removed. The effluent liquor has a BOD between 5,000 and 9,000 mg/l. The residual solids can be dewatered by vacuum filtration or disposed of in lagoons or drying beds.

Fungal Digestion

A considerable amount of work has been done on the use of fungi in the continuous oxidation of food processing wastes. Fungi Imperfecti can convert organic matter into a mycelium with a sufficiently high protein content for use as an animal feed supplement. The work that has been done involves principally wastes from corn and pea processing operations. However, consideration has been given to applying the process to other food industry wastes. While fungal digestion cannot presently be considered as a fully proven process, its further development could result in a significant new process approach for treating cannery wastes with the production of a by-product with economic value. There is one drawback existing in the development of this system, which is the difficulty to harvest the finer mycelium. Therefore, more study is needed to be done in this area in order to reduce this cost of separation. New materials of construction which permit the construction of more durable and finer mesh screen cloths will make this separation economically feasible in the near future.

SECTION VIII

COST, ENERGY, AND OTHER NON-WATER QUALITY ASPECTS

INTRODUCTION

This section will discuss and summarize the cost of treatment and control technologies described in Section VII and will estimate the cost incurred in applying various combinations and/or permutation of pollution control technologies to achieve best practicable and best available effluent reductions. The sequence of treatment components is given in Table 27 for each effluent reduction level for each of the five subcategories. Best practicable effluent reduction is attainable through the application of secondary biological treatment (Levels B or E) or land treatment (Level D). Best available effluent reduction is attainable through the application of additional biological or advanced treatment (Level C or F or G). The subsequent analysis will also describe energy requirements and the non- water quality aspects (including sludge disposal) of the levels of technology.

The information presented in Sections VII and VIII provide the background for the rationale supporting the effluent guidelines presented in Sections IX, X and XI.

IN-PLANT CONTROL COSTS

Raw Material Cleaning

One possibility for reducing processing plant waste loads is to do the raw material cleaning in the field.

In the case of apples and potatoes, this is not a practical approach because most of the harvest goes into storage prior to processing.

In the case of citrus, it is practical to consider field washing of the fruit when it is picked. The presently used washing equipment could be assembled in a portable module along with a recirculated wash water system. The fruit would be washed as it is loaded into the trucks for transportation to the processing plant.

Since there is only a small waste load generated in washing good quality fruit, the only real benefit which would be derived from cleaning in the field is a reduction in the volume of water used by the citrus processor, and, thus, there would be a smaller quantity of water to treat or dispose of by land irrigation.

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The equipment cost for field washing would be equal to or greater than that already installed in the processing plant for washing as it is received.

Thus, the requirement of field washing citrus is rejected for the following reasons:

1. The processor would not have close control of the washing/cleaning procedure.
2. There would be no cost benefit to the processor. The cost of field washing would offset the cost of treating the additional quantities of wash water at the processing plant.
3. The processor presently has available water from other processing areas available for fruit washing.

Peel Removal

The peel is normally removed from apples by the use of mechanical knives which can be adjusted to remove the desired amount of imperfections. Mechanical peeling has a high labor cost and creates a large cleanup of solid wastes which adhere to equipment surfaces and spill onto the floor. While it is hoped these solids will be collected and processed into additional products, no change from mechanical peeling is recommended.

Citrus segment processing employs only mechanical peeling. The peeled fruit is treated with caustic to remove rag and segment membranes. No change is recommended.

Potatoes are treated with steam, wet lye or dry caustic systems prior to peel removal. In Section IV processing plant effluent differences attributable to peeler system were negligable. However, if water sprays are used to remove the peel after treatment, the waste effluent load must be higher than if water sprays are not used.

If the treated peel is removed by rubber abrading and brushing with added water, this waste load does not enter the waste effluent from the plant. Information from vendors indicates that a rubber abrading installation might achieve approximately a 25 per cent reduction in water usage, a 40 per cent reduction in BOD_5, and a 65 per cent reduction in suspended solids.

Therefore, it is recommended (but not required) that the water spray system for the removal of treated peelings be replaced with the rubber abrading system with minimal water usage for brushing.

Capital costs for an installation in a 589.6 kkg/day (650 ton/day) potato processing plant are estimated to be $120,000 while annual operating cost is estimated to be $12,000.

Sorting, Trimming and Slicing

Sorting, trimming and slicing generate wastes for all three commodities that are directly attributed to the cutting of the fruit or vegetable. For example, the larger the percentage of blemishes to be removed, the greater the amount of cutting, and the higher the BOD_5 load released (excluding the blemish). Some water volumes can be reduced, but this will not reflect in a reduction in the total waste load, but will produce a more concentrated waste effluent.

There are no in-plant changes which could appreciably reduce waste loads in sorting, trimming and slicing, with the exception of potato processing, where raw starch could be recovered as a concentrated slurry by the use of hydroclcnes. This application is experimental and its practicability may depend on the value of the recovered starch.

Transport

Replacement of water transport systems with mechanical conveyors is recommended except where the water is, also, serving some other function such as washing or cooling the product. It is difficult to estimate this replacement cost since the size of the processing plants as well as the amount of conveying within each plant varies widely. Each processing plant may have to be evaluated separately.

Blanching

Apple slices are blanched two to six minutes at 82 C (180 F) prior to canning. Steam blanching is preferred to water blanching resulting in the use of reduced quantities of water. Hot-water blanching of potatoes is preferred because of the large amount of leachables which must be removed during this process step. Steam or experimental hot-gas blanching does not have the ability to remove large quantities of solubles from the product.

No blanching is used in citrus processing.

Cleanup

Cleanup is one of the largest uses of water for all three commodities. This usage may be reduced considerably by adopting the good management practices previously listed.

The capital cost of adopting this practice is nominal. Operating costs should not increase significantly, since the added labor cost, if any, would be largely offset by a reduction in water cost and treatment costs.

In-Plant Reuse of Water

The reuse of water within a food processing plant may be put into one of two categories: (1) water which comes in direct contact with the fruit or vegetable and (2) water which contacts the product in an indirect manner.

Direct Contact: Conservation of water which is in direct contact with the product can be effected by imposition of a counter flow system. For example, the water that is used to cool the product after blanching might be sequentially used in the blanching step and then possibly in the washing/ cleaning step. It has been estimated that one-third less water is used in a counter flow system than in a recirculation system where the water is recirculated within a given portion of the process. There is, also, less danger of bacteria growth in a once-through counter flow system than a recirculation system.

Indirect Contact: Some typical uses of water which does not contact the product directly are can cooling, barometric condenser, heat exchangers, refrigeration system, etc. All of these cooling systems can use a lower quality water than that which contacts the fruit or vegetable and, since this cooling water normally has a low BOD content, it is more amenable to recirculation and reuse. Cooling towers or ponds are generally employed for removal of heat in the recirculation of water.

The citrus industry is the largest user of cooling water and therefore offers the greatest potential for water savings. Very little process water comes in direct contact with the fruit (fruit washing and segment rinsing). Thus, the major portion of the water (cooling water) in a citrus plant could be reused with the addition of either cooling towers or ponds. It is, therefore, recommended that cooling towers or ponds be utilized to recirculate cooling waters. Capital costs for cooling towers for a 3630 kkg/day (4000 ton/day) plant are estimated from plant CI-135 to be $75,000 and annual operating costs are estimated to be $7,500. These costs are based on actual industry cooling tower construction costs in 1971 dollars based on typical small and large citrus plants.

Each processing plant, whether it is apples, citrus or potatoes, must make its own economic assessment on in-plant water reuse. Since most plants have wide variation in their processing methods and plant layouts, each reuse of water must be evaluated on the following factors:

1. Cost of in-plant treatment.
2. Cost of fresh water.
3. The effect of reused water on product quality.

WASTE EFFLUENT TREATMENT AND CONTROL COSTS

This section develops capital costs and operating costs for six (Levels B-G) levels of waste effluent treatment for both large and small typical plants within each of the five subcategories. In addition, we have estimated that total U.S. investment required to meet each of these six levels of treatment for each of the five subcategories as well as the pertinent apple, citrus, and potato segment of the canned and preserved fruits and vegetables industry.

Effectiveness of Waste Treatment Systems

Table 26 presents typical waste load reductions that may be expected by the application of various treatment systems to organic wastes. The systems include those that we have previously classified in Section VII as preliminary, primary, biological (secondary), advanced and ultimate.

Parameters for Cost Estimating

The raw water usage and raw waste loading used as the basis for estimating costs are those listed as average industry practice for each of five subcategories as previously set forth in Section V (Tables 19 - 21). Plants in each of the subcategories have been segmented into two groups represented by a typical small plant or by a typical large plant. The typical small plants are 91 kkg/day (100 ton/day) for both apple subcategories, 180 kkg/day (200 ton/day) for dehydrated potato products, and 360 kkg/day (400 ton/day) for citrus and frozen potato products. The typical large plants are 450 kkg/day (500 ton/day) for apple juice only, 540 kkg/day (600 ton/day) for dehydrated potato products, 910 kkg/day (1000 ton/day) for apple products except apple juice and frozen potato products, and 3630 kkg/day (4000 ton/day) for citrus products.

TABLE 26

EFFECTIVENESS AND APPLICATION OF WASTE TREATMENT SYSTEMS

Treatment System	Application	Waste Load Reduction
Flotation	Preliminary	BOD 30% Removal SS 80% Removal
Flotation with pH control & Flocculants added	Preliminary	BOD 30% Removal SS 80% Removal
Sedimentation	Primary	BOD 50 to 80% Removal
Aerated Lagoons	Biological	BOD 50 to 99% Removal
Aerobic Lagoons	Biological	BOD 50 to 99% Removal
Shallow Lagoons	Biological	BOD 50 to 99% Removal
Trickling Filter	Biological	BOD 70 to 90% Removal
Anaerobic & Aerobic Lagoons	Biological	BOD 95% Removal
Anaerobic, Aerated, & Aerobic Lagoons	Biological	BOD 99% Removal
Anaerobic Contact Process	Biological	BOD 90 to 95% Removal
Activated Sludge	Biological	BOD 90 to 95% Removal
Extended Aeration	Biological	BOD 90 to 95% Removal
Chlorination	Advanced	Disinfectant
Sand Filter	Advanced	BOD to 5-10 mg/l SS to 3-8 mg/l
Microscreen	Advanced	BOD to 10-20 mg/l SS to 10-15 mg/l
Electrodialysis	Advanced	Total Dissolved Solids 90% Removal
Ion Exchange	Advanced	Salt 90% Removal
Carbon Adsorption	Advanced	BOD to 98% as Colloidal Organic
Chemical Precipitation	Advanced	Phosphorus 85-95% Removal
Reverse Osmosis	Advanced	Salt to 5 mg/l TDS to 20 mg/l
Spray Irrigation	Ultimate	Complete
Flood Irrigation	Ultimate	Complete
Ponding & Evaporation	Ultimate	Complete

Levels of Treatment Technology

For the purpose of determining the cost effectiveness of various levels of treatment it was necessary to select practical treatment systems to achieve these levels. The system design used to obtain a given level of treatment varies from subcategory to subcategory and there are numerous combinations of treatment steps that will achieve the same level of treatment. In general the treatment systems consist of one or more of the following five classes of treatment technology: preliminary, primary, secondary, advanced, and ultimate disposal.

Preliminary Treatment: Screens are preliminary treatment and are used to remove solids from the waste effluent streams as they are discharged from the processing plant. The screening of the waste effluent stream from a food processing plant is normally the first step in the treatment system and is the most economical method of removing large solids. This removal of solids protects other equipment from plugging or damage and reduces the size of other solids handling units. There are various types of screens which are used in these plants. The vibrating screen equipped with a 20 to 40 mesh screen cloth is generally used. In recent years because more municipal sewer assessments are based on the amount of suspended solids in the effluent and, also, because of increased emphasis on reuse of process water, there has been a concerted effort on the part of the food processor to use finer and finer mesh screens.

Primary treatment: Primary treatment is, also, used to remove solids from the waste effluent streams. Primary treatment includes sedimentation units with and without sludge disposal to remove settleable solids not removed in the preliminary screening. A clarifier of either circular or rectangular design is used for the removal of floatable and settleable solids. These clarifiers are equipped with mechanical scrapers to assist in the removal of solids that settle to the bottom or float on the top. The volume of solids that is removed from the clarifier is further concentrated by a rotary vacuum filter or a centrifuge. The concentrated solids can, usually, be sold as animal feed. Design criteria for estimating cost of primary systems for each typical size of each subcategory are primarily waste water flow and suspended solids loading (See Tables 19-21).

Primary treatment is not, generally, used in the apple or citrus industry. If a primary treatment system is present at an apple or citrus plant, it is, usually, designed without sludge disposal. In the potato processing industry, primary treatment with clarifier sludge concentration is necessary and practicable because of the high suspended solids loading. It is common practice in the potato industry to utilize dual primary clarifiers. One clarifier, is used to recover solids from the process waste water. Another clarifier is used to settle silt and remove mud from the raw potato wash water. The process waste water solids are collected and concentrated by a rotary vacuum filter. In the cost figures given in Table 28, dual clarifiers and a rotary vacuum filter are included in the sedimentation with sludge recovery cost estimates for both frozen and dehydrated potato plants.

Secondary (Biological) Treatment: Biological treatment is a secondary treatment system which is employed for a high reduction of BOD from the waste effluent stream. To achieve this high reduction in BOD a number of different biological systems may be employed: biological filters, activated sludge, aerated lagoons, anaerobic lagoons, and shallow lagoons.

Biological treatment systems are best practicable technology and multiple combinations of biological treatment systems are best available technology. The design parameters for these treatment systems are primarily total waste water flow and BOD loading (See Tables 19-21). The estimation of cost for each typical system size in each subcategory are based on these criteria.

Sand filtration, carbon adsorption, microscreening, ion exchange, electrodialysis, reverse osmosis and ultra filtration have been considered for the further reduction in BOD and the removal of undesirable soluble components from the waste stream to permit water recycle or reuse. The advanced treatment was considered as an additional component to the best practicable biological treatment system to attain best available effluent reduction.

Ultimate Disposal: For the zero discharge of pollutants, land disposal is a technology currently being used by apple, citrus and potato processors when sufficient and suitable land is available. Both land flooding and spray irrigation are accepted methods of disposal and have been used as the basis of cost estimates. The primary design parameter for irrigation systems is waste water flow (See Tables 19-21). Evaporative ponds and percolation lagoons are, also, an accepted form of ultimate disposal but have not been used in ultimate disposal cost estimates.

Effluent Reduction Levels

The classes of waste treatment systems discussed above are suitable waste treatment systems which will perform when properly operated within the design parameters and limitations of the system for apple, citrus, or potato processing wastes. Best practicable effluent reduction is attainable through the application of secondary biological treatment (Levels B or E) or through ultimate disposal by land treatment (Level

D). Best available effluent reduction is attainable through the application of advanced treatment (Levels C or F or G).

All apple, citrus, and potato subcategories regardless of waste treatment or disposal method utilize screens to remove particulate solids from the waste effluent as it leaves the plant. The higher the percentage of solids which are removed at this point the lower the waste load entering the treatment system. Screening is Level A effluent reduction for each typical size in each subcategory. Screening is also used in all other effluent reduction levels (Levels B - G).

Primary treatment is not used as universally as screening. Only in the case of the two potato subcategories is it necessary to employ primary sedimentation with sludge disposal prior to any biological treatment system or prior to land treatment. Dual primary clarifiers and a rotary vacuum filter are in the potato sedimentation with sludge disposal cost estimates. Thus, reduction levels B through G for frozen and dehydrated potato products utilize primary sedimentation.

As discussed earlier in the section under "In-Plant Reuse of Water" cooling towers or ponds are very important in handling the large cooling water volumes in the citrus industry. Thus, effluent reduction levels B and C and E through G for the citrus processing subcategory utilize cooling towers.

There are several different biological systems used to fully or partially achieve effluent levels B and C and E through G. Some biological treatment systems are dependent upon long retention times to achieve the desired waste load reduction; some are not. Large land areas may be required to accommodate some of these systems but only limited area requirements are needed if mechanical separation or collection devices such as centrifuges and filters are utilized. Higher energy, maintenance, and capital costs are required with mechanical equipment to attain comparable levels of waste reduction. Aerated lagoons with and without settling, aerobic/anaerobic lagoons, and 30 day shallow lagoons are biological systems used to attain Levels B and C effluent reduction.

Effluent levels E, F and G utilize activated sludge (secondary) treatment. Level G, also, employs an aerated lagoon. Effluent levels F and G utilize advanced treatment technology in the form of sand filtration following secondary treatment. This polishing filter removes most of the remaining BOD and suspended solids. Very low effluent levels are possible.

Level D reduction is attained through the use of screening, primary sedimentation (potato only), and a shallow lagoon before ultimate disposal through land treatment. Spray or flood irrigation is the form of land treatment used. The availability of suitable and sufficient land are limits to the utilization of this technology.

The six effluent reduction levels for each subcategory are described in detail in Table 27 by listing the sequence of waste effluent treatment technologies utilized to attain each level of effluent reduction. For example, effluent reduction Level B for the apple juice subcategory is attained through preliminary screening followed by two aerated lagoons (no settling) in series.

Investment and Annual Operating Costs - Model Plant

The estimated investment to obtain the various treatment levels is shown for both small and large plants for each of the five subcategories in Tables 30-34. These costs are generated from Tables 28 and 29 which list investment and annual cost for various preliminary, primary, secondary, advanced and ultimate treatment systems for small and large plants. The annual operating costs corresponding to the investment costs are also shown in these tables. Investment costs for specific waste treatment systems are dependent on the waste water flow, BOD loading and suspended solids loading. The investment costs were calculated on the basis of raw waste effluent data from Tables 19-21 with information supplied, from food processing equipment manufacturers, engineering contractors and consultants. Costs compare satisfactorily with investment costs collected individually from apple, citrus and potato processors. All costs are reported in August 1971 dollars. Percentage factors were added to the basic system estimate for design and engineering (10%) and for contingencies and omissions (15%). Land costs were estimated to be $4940 per hectare ($2000 per acre).

Variations exist in plant water flows and BOD_5 loadings; there exist inherent inaccuracies in cost estimating which could reflect an error approaching 20 to 25 percent.

The components of annual cost include capital cost, depreciation, operation and maintenance costs, and energy and power costs. The capital interest costs are assumed to be 8 percent, depreciation costs are assumed to be 5 percent and taxes and insurance are assumed to be 3 percent of the investment.

Investment and Annual Operating Costs - Subcategory

The total investment costs for each alternative treatment level is calculated for each of the five subcategories in Table 35. The investment cost are given for both typical small plants and typical large plants. The total annual costs for small and large plants in each subcategory are included in the tabulation. Also, each treatment level includes screening (Level A).

The total investment (or total annual) costs are calculated by multiplying the treatment level's capital cost ($1000) times the annual raw material processed by the subcategory typical plant (million kkg (ton) / year) and by dividing by the capacity (kkg (ton)/ day) and by the processing season (day/year). There are assumptions with regard to season and annual raw material processed. The season for apples is assumed to be 50 days/year, 216 days/year for citrus, and 240 days/ year for potatoes. With regard to the annual raw material processed, 0.36 and 1.09 million kkg (0.4 and 1.2 million tons) of the annual apple crop are assumed to be processed to apple juice and apple products except juice respectively. The 6.4 million ton potato crop is assumed to be processed equally into frozen and dehydrated products. This assumption is possible because the model plants processing frozen products are almost twice as large as the dehydrated potato model plants. A further assumption is that annual raw material is processed equally by the typical small plant and by the typical large plant within each subcategory. In this rationale, economic impacts for both small plants and large plants are thereby considered.

The total investment costs for achieving each level of effluent reduction are listed for each subcategory and each industry in Table 36. The total annual costs are listed in Table 37. The total investment and annual costs from Table 35 are summed to calculate these total costs for Tables 36 and 37. The assumptions are that all plants are subject to each treatment level and that no present treatment facilities exist.

The cost impact on the apple, citrus, and potato industry as a result of applying each level of effluent reduction is given in Table 38. Two assumptions have been made to develop this table. First, all plants are not subject to each level of effluent reduction. For each commodity, a percentage of the industry was found to be disposing of their waste to municipal systems, a percentage through land treatment and a percentage by secondary treatment techniques. The results of our apple, citrus and potato processing survey are indicated below:

Industry	Municipal Treatment (%)	Secondary Treatment (%)	Land Treatment (%)
Apple	26	20	54
Citrus	12	32	56
Potato	10	33	57

These secondary treatment factors are applied to effluent reduction Levels B, C, E, F and G. The land treatment factors are applied to Level D. The municipal treatment factors are not applied because these plants are outside the scope of this effort.

The second assumption is that treatment facilities do exist and that only a portion of the industry subject to an effluent reduction level will have to either construct facilities or upgrade existing facilities. It was assumed that one-third of the industry would need to construct or upgrade facilities to achieve Levels B, D, and E and ninty-nine percent of the industry would need to construct additional facilities to achieve Levels C, F and G. These factors are applied to the capital costs in Table 36.

The result of Table 38 is that the capital investments for each subcategory can be related to each level of effluent reduction. Levels B and E are the effluent reduction attainable through the application of best practicable control technology currently available. Levels C, F and G are the effluent reductions attainable through the application of the best available control technology economically achievable. Table 39 is a tabulation of the total annual costs for each subcategory to meet each level of effluent reduction.

The investment costs of meeting Levels B and D by 1977 are $2.2 million for apples, $6.2 million for citrus and $8.68 million for potatoes for a total industry cost of $17.1 million. The investment cost of meeting similar levels of effluent reduction through application of more expensive treatment technology represented by Levels E and D by 1977 are $4.7 million for apples, $10.0 million for citrus, and $11.4 million for potatoes for a total industry cost of $26.10 million. The investment costs of meeting Levels B, C, and D by 1983 are $3.7 million for apples, $12.0 million for citrus, and $13.4 million for potatoes for a total industry cost of $29 million. The investment cost of meeting similar levels of effluent reduction through application of more expensive treatment technology represented by Levels E, F or G, and D by 1983 are $6.1 or $ 6.7 million for apples, $12.3 or $14.1 million for citrus, and $13.5 or $15.1 million for potatoes for a total industry cost of $32 or $36 million.

Therefore, the total industry (apple, citrus, and potato) investment costs to meet 1977 levels of effluent reduction range from $17.1 to $26.1 million and the total industry costs to meet 1977 and 1983 levels of effluent reduction range from $29 to $36 million.

TABLE 27

EFFLUENT TREATMENT SEQUENCE BY SUBCATEGORY TO ACHIEVE VARIOUS LEVELS OF EFFLUENT REDUCTION

TREATMENT COMPONENT (SEQUENTIAL)	APPLE JUICE LEVEL						APPLE PRODUCTS (EXCEPT JUICE) LEVEL						CITRUS PRODUCTS LEVEL						DEHYDRATED POTATO PRODUCTS LEVEL						FROZEN POTATO PRODUCTS LEVEL					
	B	C	D	E	F	G	B	C	D	E	F	G	B	C	D	E	F	G	B	C	D	E	F	G	B	C	D	E	F	G
LEVEL A SCREENING	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
COOLING TOWER													2	2	2	2	2	2												
PRIMARY SEDIMENTATION																			2	2	2	2	2	2	2	2	2	2	2	2
ANAEROBIC/AEROBIC LAGOON														3					3	3					3	3				
AERATED LAGOON (SETTLING)		2						2					3	4					4	4					4	4				
AERATED LAGOON (NO SETTLING)	2	3					2	3					4	5						5						5				
AERATED LAGOON (NO SETTLING)	3	4					3	4												6						6				
SHALLOW LAGOON (30 day retention)			2					5	2					6	3					7	3					7	3			
ACTIVATED SLUDGE				2	2	2				2	2	2				3	3	3				3	3	3				3	3	3
AERATED LAGOON (NO SETTLING)						3						3						4						4						4
SAND FILTRATION					3	4					3	4					4	5					4	5					4	5
SPRAY IRRIGATION			3						3						4						4						4			

TABLE 28

INVESTMENT AND ANNUAL COSTS PRELIMINARY, PRIMARY & BIOLOGICAL WASTE TREATMENT SYSTEMS

SMALL PLANTS

WASTE TREATMENT SYSTEM	APPLE PRODUCTS ($1,000)		APPLE JUICE ($1,000)		CITRUS JUICE, OIL, SEG. & PEEL PRODUCTS ($1,000)		POTATOES DEHYDRATED ($1,000)		POTATOES FROZEN ($1,000)	
	CAPITAL	ANNUAL	CAPITAL	ANNUAL	CAPITAL	ANNUAL	CAPITAL	ANNUAL	CAPITAL	ANNUAL
Preliminary										
- Screen	2.0	1.0	1.0	.3	6.2	3.5	3.3	1.6	6.2	3.5
Primary										
- Sedimentation w/ Sludge Disposal	48.0	7.2	50.0	4.5	190.0	28.0	95.0	14.0	176.0	27.5
- Sedimentation w/out Sludge Disposal	25.0	3.0	10.0	1.5	92.0	15.9	44.0	7.5	90.0	16.5
Biological										
- Shallow Lagoon w/ 30-Day Retention	15.0	2.0	10.0	1.0	63.0	8.0	30.0	3.8	63.0	7.8
- Shallow Lagoon w/ 90-Day Retention	50.0	7.0	19.0	6.3	126.0	15.0	75.0	10.5	125.0	15.0
- Aerated Lagoon w/Settling	27.0	9.2	10.0	5.8	114.0	22.8	60.0	14.0	113.0	22.2
- Aerated Lagoon w/out Settling	15.0	5.4	6.0	2.0	81.0	18.4	40.0	11.0	80.0	18.0
- Anaerobic/Aerobic Ponding	70.0	17.0	16.0	.32	212.0	44.8	115.0	20.0	210.0	44.0
- Trickling Filter	130.0	4.0	250.0	3.0	680.0	30.0	300.0	13.0	670.0	30.0
- Activated Sludge	240.0	8.5	151.0	5.0	725.0	39.0	400.0	17.0	720.0	36.0
- Spray Irrigation w/Runoff	25.0	12.0	14.0	7.5	144.0	33.5	55.0	20.0	140.0	33.0

LARGE PLANTS

WASTE TREATMENT SYSTEM	APPLE PRODUCTS ($1,000)		APPLE JUICE ($1,000)		CITRUS JUICE, OIL, SEG. & PEEL PRODUCTS ($1,000)		POTATOES DEHYDRATED ($1,000)		POTATOES FROZEN ($1,000)	
	CAPITAL	ANNUAL	CAPITAL	ANNUAL	CAPITAL	ANNUAL	CAPITAL	ANNUAL	CAPITAL	ANNUAL
Preliminary										
- Screen	5.2	2.8	2.2	.8	19.2	12.8	6.9	4.0	11.0	6.7
Primary										
- Sedimentation w/ Sludge Disposal	150.0	22.5	62.0	9.3	678.4	121.9	200.0	32.0	345.0	60.0
- Sedimentation w/out Sludge Disposal	70.0	12.5	24.0	3.9	384.0	72.0	103.0	18.0	195.0	35.5
Biological										
- Shallow Lagoon w/ 30-Day Retention	50.0	6.5	15.0	2.5	240.0	28.0	72.0	9.0	124.0	14.7
- Shallow Lagoon w/ 90-day Retention	105.0	13.0	45.0	7.0	492.8	46.7	142.0	16.3	243.0	24.5
- Aerated Lagoon w/Settling	93.0	19.8	34.0	11.2	504.0	76.2	130.0	25.0	245.0	39.2
- Aerated Lagoon w/out Settling	65.0	15.8	22.0	6.6	352.0	54.7	92.0	20.0	175.0	35.0
- Anaerobic/Aerobic Ponding	160.0	34.0	50.0	11.0	787.2	142.1	250.0	52.0	450.0	83.0
- Trickling Filter	540.0	23.0	170.0	6.0	3,024.0	132.8	780.0	35.0	1,480.0	67.0
- Activated Sludge	595.0	30.5	270.0	11.0	2,960.0	174.4	805.0	44.0	1,470.0	85.0
- Spray Irrigation w/ Runoff	100.0	28.0	320.0	13.5	758.4	86.4	168.0	37.0	359.0	49.0

TABLE 29

INVESTMENT AND ANNUAL COSTS ADVANCED WASTE TREATMENT SYSTEMS & ULTIMATE DISPOSAL

SMALL PLANTS

WASTE TREATMENT SYSTEM	APPLE PRODUCTS ($1,000) CAPITAL	APPLE PRODUCTS ($1,000) ANNUAL	APPLE JUICE ($1,000) CAPITAL	APPLE JUICE ($1,000) ANNUAL	CITRUS JUICE, OIL, SEG. & PEEL PRODUCTS ($1,000) CAPITAL	CITRUS JUICE, OIL, SEG. & PEEL PRODUCTS ($1,000) ANNUAL	POTATOES DEHYDRATED ($1,000) CAPITAL	POTATOES DEHYDRATED ($1,000) ANNUAL	POTATOES FROZEN ($1,000) CAPITAL	POTATOES FROZEN ($1,000) ANNUAL
Chlorination	2.6	.41	1.3	.24	13.95	2.5	5.8	.95	13.0	2.3
Chemical Secondary Treatment	100.0	22.5	40.0	11.0	675.0	107.0	260.0	49.0	620.0	98.0
Sand Filtration	38.0	7.9	24.0	5.8	111.1	15.3	61.0	10.1	107.0	14.9
Microscreening	11.0	3.1	6.0	1.7	69.5	15.8	26.5	7.0	65.0	14.9
Nitrogen Removal	38.0	3.3	22.0	1.3	112.0	15.3	60.0	7.0	105.0	14.75
Activated Carbon	72.0	3.6	36.0	1.7	420.0	22.5	175.0	9.0	410.0	21.5
Ultrafiltration	200.0	51.0	110.0	34.0	1,060.0	207.0	440.0	100.0	995.0	195.0
Ultimate Disposal										
(Based on Flow)	32.0	8.0	15.0	3.8	242.3	60.6	88.8	22.2	223.9	56.0
(Based on BOD_5)	11.2	2.8	2.8	0.7	76.8	19.2	21.5	5.4	65.3	16.3

LARGE PLANTS

WASTE TREATMENT SYSTEM	APPLE PRODUCTS ($1,000) CAPITAL	APPLE PRODUCTS ($1,000) ANNUAL	APPLE JUICE ($1,000) CAPITAL	APPLE JUICE ($1,000) ANNUAL	CITRUS JUICE, OIL, SEG. & PEEL PRODUCTS ($1,000) CAPITAL	CITRUS JUICE, OIL, SEG. & PEEL PRODUCTS ($1,000) ANNUAL	POTATOES DEHYDRATED ($1,000) CAPITAL	POTATOES DEHYDRATED ($1,000) ANNUAL	POTATOES FROZEN ($1,000) CAPITAL	POTATOES FROZEN ($1,000) ANNUAL
Chlorination	10.5	1.8	5.5	1.0	64.8	11.52	15.0	2.7	31.0	5.9
Chemical Secondary Treatment	500.0	83.0	250.0	48.0	3,328.0	448.0	750.0	113.0	1,580.0	217.5
Sand Filtration	92.5	13.5	62.5	10.25	419.2	46.7	120.0	16.2	212.0	24.5
Microscreening	52.0	12.5	27.0	7.0	244.8	40.8	78.0	17.0	140.0	24.75
Nitrogen Removal	93.0	12.5	60.0	7.0	438.4	40.8	121.0	17.0	220.0	24.75
Activated Carbon	330.0	17.0	180.0	9.0	1,408.0	84.0	480.0	26.0	820.0	47.0
Ultrafiltration	800.0	165.0	450.0	100.0	5,088.0	896.0	1,180.0	230.0	2,450.0	445.0
Ultimate Disposal										
(Based on Flow)	144.0	36.0	75.2	18.8	1,508.3	377.1	276.2	69.1	660.3	165.1
(Based on BOD_5)	144.0	36.0	14.2	2.0	768.0	192.0	71.7	17.9	163.5	40.9

TABLE 30

INVESTMENT AND ANNUAL COSTS BY EFFLUENT REDUCTION LEVEL FOR APPLE JUICE (Sole Product) SUBCATEGORY FOR TYPICAL SMALL PLANT (100 TPD) AND LARGE PLANT (500 TPD)

TREATMENT COMPONENT	COST OF EFFLUENT REDUCTION ALTERNATIVE ($1,000)											
	LEVEL B		LEVEL C		LEVEL D		LEVEL E		LEVEL F		LEVEL G	
	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large
LEVEL A: SCREENING	1.0	2.2	1.0	2.2	1.0	2.2	1.0	2.2	1.0	2.2	1.0	2.2
PRIMARY SEDIMENTATION												
SHALLOW LAGOON (30 day retention)					10.0	15.0						
AERATED LAGOON (Settling)			10.0	34.0								
AERATED LAGOON (No Settling)	12.0	44.0	12.0	44.0							6.0	22.0
ANAEROBIC/AEROBIC LAGOON												
ACTIVATED SLUDGE							151.0	270.0	151.0	270.0	151.0	270.0
SAND FILTRATION									24.0	62.5	24.0	62.5
SPRAY IRRIGATION					15.0	75.2						
TOTAL CAPITAL INVESTMENT ($1000)	13.0	46.2	23.0	80.2	26.0	92.4	152.0	272.2	176.0	334.7	182.0	356.7
TOTAL ANNUAL COST ($1000)	4.3	14.0	10.0	25.2	5.1	22.1	5.3	11.8	11.1	22.05	13.1	28.6

TABLE 31

INVESTMENT AND ANNUAL COSTS BY EFFLUENT REDUCTION LEVEL FOR APPLE PRODUCTS EXCEPT JUICE (ONLY) SUBCATEGORY FOR TYPICAL SMALL PLANT (100 TPD) AND LARGE PLANT (1,000 TPD)

	COST OF EFFLUENT REDUCTION ALTERNATIVE ($1,000)											
	LEVEL B		LEVEL C		LEVEL D		LEVEL E		LEVEL F		LEVEL G	
TREATMENT COMPONENT	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large
LEVEL A: SCREENING	2.0	5.2	2.0	5.2	2.0	5.2	2.0	5.2	2.0	5.2	2.0	5.2
PRIMARY SEDIMENTATION												
SHALLOW LAGOON (30 day retention)			15.0	50.0	15.0	50.0						
AERATED LAGOON (Settling)			27.0	93.0								
AERATED LAGOON (No Settling)	30.0	130.0	30.0	130.0							15.0	65.0
ANAEROBIC/AEROBIC LAGOON												
ACTIVATED SLUDGE							240.0	595.0	240.0	595.0	240.0	595.0
SAND FILTRATION									38.0	92.5	38.0	92.5
SPRAY IRRIGATION					32.0	144.0						
TOTAL CAPITAL INVESTMENT ($1,000)	32.0	135.2	74.0	278.2	49.0	199.2	242.0	600.2	280.0	692.7	295.0	757.7
TOTAL ANNUAL COST ($1,000)	11.8	34.4	42.2	60.7	11.0	45.3	9.5	33.3	17.4	46.8	22.8	79.2

TABLE 32

INVESTMENT AND ANNUAL COSTS BY EFFLUENT REDUCTION LEVEL FOR CITRUS PRODUCTS SUBCATEGORY FOR TYPICAL SMALL PLANTS (40C TPD) AND LARGE PLANT (4,000 TPD)

TREATMENT COMPONENT	COST OF EFFLUENT REDUCTION ALTERNATIVE ($1,000)											
	LEVEL B		LEVEL C		LEVEL D		LEVEL E		LEVEL F		LEVEL G	
	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large
LEVEL A: SCREENING	6.2	19.2	6.2	19.2	6.2	19.2	6.2	19.2	6.2	19.2	6.2	19.2
PRIMARY SEDIMENTATION												
COOLING TOWER	50.0	75.0			50.0	75.0	50.0	75.0	50.0	75.0	50.0	75.0
SHALLOW LAGOON (30 day retention)		63.0	240.0	63.0	240.0							
AERATED LAGOON (Settling)	114.00	504.0	114.0	504.0								
AERATED LAGOON (No Settling)	81.0	352.0	81.0	352.0							81.0	352.0
ANAEROBIC/AEROBIC LAGOON		212.0	787.2									
ACTIVATED SLUDGE							725.0	2960	725.0	2960	725.0	2960
SAND FILTRATION									111.1	419.2	111.1	419.2
SPRAY IRRIGATION					242.3	1508.3						
TOTAL CAPITAL INVESTMENT ($1,000)	251.2	950.2	526.2	1977.4	311.5	1767.5	781.2	3054.2	892.3	3473.4	973.3	3825.4
TOTAL ANNUAL COSTS ($1,000)	49.7	151.2	102.5	321.9	72.1	417.9	47.5	194.7	62.8	241.4	81.2	296.1

TABLE 33

INVESTMENT AND ANNUAL COSTS BY EFFLUENT REDUCTION LEVEL FOR FROZEN POTATO PRODUCTS SUBCATEGORY FOR TYPICAL SMALL PLANT (400 TPD) AND LARGE PLANT (1000 TPD)

COST OF EFFLUENT REDUCTION ALTERNATIVE ($1000)

	LEVEL B		LEVEL C		LEVEL D		LEVEL E		LEVEL F		LEVEL G	
TREATMENT COMPONENT	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large
LEVEL A: SCREENING	6.2	11.0	6.2	11.0	6.2	11.0	6.2	11.0	6.2	11.0	6.2	11.0
PRIMARY SEDIMENTATION	176.0	345.0	176.0	345.0	176.0	345.0	176.0	345.0	176.0	345.0		
SHALLOW LAGOON (30 day retention)			63.0	124.0	63.0	124.0						
AERATED LAGOON (Settling)	113.0	245.0	113.0	245.0								
AERATED LAGOON (No Settling)			160.0	350.0							80.0	175.0
ANEROBIC/AEROBIC LAGOON	210.0	450.0	210.0	450.0								
ACTIVATED SLUDGE							720.0	1470	720.0	1470	720.0	1470
SAND FILTRATION									107.0	212.0	107.0	212.0
SPRAY IRRIGATION					223.9	660.3						
TOTAL CAPITAL INVESTMENT ($1,000)	505.2	1051.0	728.2	1525.0	469.1	1140.3	902.2	1826.0	1009.2	2038.0	1089.2	2213.0
TOTAL ANNUAL COST ($1,000)	100.7	188.9	144.5	273.6	94.8	246.5	67.0	151.7	81.9	176.2	99.9	211.2

TABLE 34

INVESTMENT AND ANNUAL COSTS BY EFFLUENT REDUCTION LEVEL FOR DEHYDRATED POTATO PRODUCTS SUBCATEGORY FOR TYPICAL SMALL PLANT (200 TPD) AND LARGE PLANT (600 TPD)

COST OF EFFLUENT REDUCTION ALTERNATIVE ($1,000)

TREATMENT COMPONENT	LEVEL B		LEVEL C		LEVEL D		LEVEL E		LEVEL F		LEVEL G	
	Capital	Annual	Capital	Annual	Capital	Annual	Capital	Annual	Capital	Annual	Capital	Annual
LEVEL A: SCREENING	3.3	6.9	3.3	6.9	3.3	6.9	3.3	6.9	3.3	6.9	3.3	6.9
PRIMARY SEDIMENTATION	95.0	200.0	95.0	200.0	95.0	200.0	95.0	200.0	95.0	200.0	95.0	200.0
SHALLOW LAGOON (30 day retention)			30.0	72.0	30.0	72.0						
AERATED LAGOON (Setting)	60.0	130.0	60.0	130.0								
AERATED LAGOON (No Settling)			80.0	184.0							40.0	92.0
ANAEROBIC/AEROBIC LAGOON	115.0	250.0	115.0	250.0								
ACTIVATED SLUDGE							400.0	805.0	400.0	805.0	400.0	805.0
SAND FILTRATION									61.0	120.0	61.0	120.0
SPRAY IRRIGATION					88.8	276.2						
TOTAL CAPITAL INVESTMENT ($1000)	273.3	586.9	383.3	842.9	217.1	555.1	498.3	1011.9	559.3	1131.9	599.3	1223.9
TOTAL ANNUAL COST ($1000)	49.6	113.0	75.4	162.0	41.6	114.1	32.6	80.0	42.7	96.2	53.7	116.2

TABLE 35

TOTAL INVESTMENT AND ANNUAL COST FOR EACH LEVEL OF EFFLUENT REDUCTION BY SUBCATEGORY AND SIZE

SUBCATEGORY	ALTERNATIVE TREATMENT LEVEL	CAPITAL COST ($1000)		SEASON (DA/YR)	RAW MATERIAL (TON/YEAR)	TOTAL INVESTMENT ($1,000,000)		TOTAL ANNUAL COST ($1000)	
		Small	Large			Small	Large	Small	Large
APPLE JUICE (Sole Product)	B	13.0	46.2	50	200,000	0.52	0.37	0.17	0.11
	C	23.0	80.2	50	200,000	0.92	0.64	0.40	0.20
	D	26.0	92.4	50	200,000	1.04	0.74	0.20	0.18
	E	152.0	272.2	50	200,000	6.08	2.18	0.21	0.09
	F	176.0	334.7	50	200,000	7.04	2.68	0.44	0.18
	G	182.0	356.7	50	200,000	7.28	2.85	0.52	0.23
APPLE PRODUCTS (Except Juice)	B	32.0	135.2	50	600,000	3.84	1.62	1.42	0.41
	C	74.0	278.2	50	600,000	8.88	3.34	5.09	0.73
	D	49.0	199.2	50	600,000	5.88	2.39	1.32	0.54
	E	242.0	600.2	50	600,000	29.04	7.20	1.14	0.40
	F	280.0	692.7	50	600,000	33.60	8.31	2.09	0.56
	G	295.0	757.7	50	600,000	35.40	9.09	2.74	0.95
CITRUS PRODUCTS	B	251.2	905.2	216	4,200,000	12.21	4.62	2.42	0.74
	C	526.2	1977.4	216	4,200,000	25.57	9.61	4.98	1.56
	D	311.5	1767.5	216	4,200,000	15.14	8.59	3.50	2.03
	E	781.2	3054.2	216	4,200,000	37.97	14.84	2.31	0.95
	F	892.3	3473.4	216	4,200,000	43.37	16.88	3.05	1.17
	G	973.3	3825.4	216	4,200,000	47.30	18.59	3.95	1.44
FROZEN POTATO PRODUCTS	B	505.2	1051.0	240	1,600,000	8.39	6.00	1.67	1.26
	C	728.2	1525.0	240	1,600,000	12.09	10.16	2.40	1.82
	D	469.1	1140.3	240	1,600,000	7.79	7.59	1.57	1.64
	E	902.2	1826.0	240	1,600,000	14.98	12.16	1.11	1.01
	F	1009.2	2038.0	240	1,600,000	16.75	13.57	1.36	1.17
	G	1089.2	2213.0	240	1,600,000	18.08	14.74	1.66	1.41
DEHYDRATED POTATO PRODUCTS	B	273.3	586.9	240	1,600,000	9.10	6.51	1.65	1.25
	C	383.3	842.9	240	1,600,000	12.76	9.36	2.51	1.80
	D	217.1	555.1	240	1,600,000	7.23	6.16	1.39	1.27
	E	498.3	1011.9	240	1,600,000	16.59	11.23	1.09	0.89
	F	559.3	1131.9	240	1,600,000	18.62	12.56	1.42	1.07
	G	599.3	1223.9	240	1,600,000	19.96	13.59	1.79	1.29

$$\text{TOTAL INVESTMENT COST (\$1,000,000)} = \frac{\text{(CAPITAL COST) X (RAW TONS PROCESSED)}}{\text{(CAPACITY) X (SEASON)}}$$

TABLE 36 TOTAL SUBCATEGORY AND INDUSTRY INVESTMENT COST FOR EACH LEVEL OF EFFLUENT REDUCTION

		TOTAL INVESTMENT FOR EFFLUENT REDUCTION LEVEL ($1,000,000)					
SUBCATEGORY	SIZE	LEVEL B	LEVEL C	LEVEL D	LEVEL E	LEVEL F	LEVEL G
APPLE JUICE (SOLE PRODUCT)	SMALL	0.52	0.92	1.04	6.08	7.04	7.28
	LARGE	0.37	0.64	0.74	2.18	2.68	2.85
TOTAL		0.89	1.56	1.78	8.26	9.72	10.13
APPLE PRODUCTS (EXCEPT JUICE)	SMALL	3.84	8.88	5.88	29.04	33.60	35.40
	LARGE	1.62	3.34	2.39	7.20	8.31	9.09
TOTAL		5.46	12.22	8.27	36.24	41.91	44.49
CITRUS PRODUCTS	SMALL	12.21	25.57	15.14	37.97	43.37	47.30
	LARGE	4.62	9.61	8.59	14.84	16.88	18.59
TOTAL		16.83	35.18	23.73	52.81	60.25	65.89
FROZEN POTATO PRODUCTS	SMALL	8.39	12.09	7.79	14.98	16.75	18.08
	LARGE	6.00	10.16	7.59	12.16	13.57	14.74
TOTAL		14.39	22.25	15.38	27.14	30.32	32.82
DEHYDRATED POTATO PRODUCTS	SMALL	9.10	12.76	7.23	16.59	18.62	19.96
	LARGE	6.51	9.36	6.16	11.23	12.56	13.59
TOTAL		15.61	22.12	13.39	27.82	31.18	33.55
APPLE TOTAL		6.35	13.78	10.05	44.50	51.63	54.62
CITRUS TOTAL		16.83	35.18	23.73	52.81	60.25	65.89
POTATO TOTAL		30.00	44.37	28.77	54.96	61.50	66.37
INDUSTRY TOTAL		53.18	93.33	62.55	152.27	173.38	186.88

TABLE 37 TOTAL SUBCATEGORY AND INDUSTRY ANNUAL COST FOR EACH LEVEL OF EFFLUENT REDUCTION

		TOTAL INVESTMENT FOR EFFLUENT REDUCTION LEVEL ($1,000,000)					
SUBCATEGORY	SIZE	LEVEL B	LEVEL C	LEVEL D	LEVEL E	LEVEL F	LEVEL G
APPLE JUICE (SOLE PRODUCT)	SMALL	0.17	.40	.20	.21	.44	.52
	LARGE	0.11	.20	.18	.09	.18	.23
TOTAL		0.28	0.60	0.38	0.30	0.62	0.75
APPLE PRODUCTS (EXCEPT JUICE)	SMALL	1.42	5.09	1.32	1.14	2.09	2.74
	LARGE	.41	.73	.54	.40	.56	.95
TOTAL		1.83	5.82	1.86	1.54	2.65	3.69
CITRUS PRODUCTS	SMALL	2.42	4.98	3.50	2.31	3.05	3.95
	LARGE	.73	1.56	2.03	.95	1.17	1.44
TOTAL		3.15	6.54	5.53	3.26	4.22	5.39
FROZEN POTATO PRODUCTS	SMALL	1.67	2.40	1.57	1.11	1.36	1.66
	LARGE	1.26	1.82	1.64	1.01	1.17	1.41
TOTAL		2.93	4.22	3.21	2.12	2.53	3.07
DEHYDRATED POTATO PRODUCTS	SMALL	1.65	2.51	1.39	1.09	1.42	1.79
	LARGE	1.25	1.80	1.27	.89	1.07	1.29
TOTAL		2.90	4.31	2.66	1.98	2.49	3.08
APPLE TOTAL		2.11	6.42	2.24	1.84	3.27	4.44
CITRUS TOTAL		3.15	6.54	5.53	3.26	4.22	5.39
POTATO TOTAL		5.83	8.53	5.87	4.10	5.02	6.15
INDUSTRY TOTAL		11.09	21.49	13.64	9.20	12.51	15.98

TABLE 38 TOTAL CAPITAL INVESTMENT TO MEET EACH LEVEL OF EFFLUENT REDUCTION

EFFLUENT LEVEL	CAPITAL INVESTMENT ($ Million)					TOTAL INVESTMENT BY LEVEL
	APPLE JUICE	APPLE PRODUCTS	CITRUS PRODUCTS	FROZEN POTATOES	DEHYDRATED POTATOES	
B (1977)	.06	.36	1.78	1.57	1.70	5.47
C (1983)	.19	1.70	7.59	4.14	3.83	17.45
D (1977)	.32	1.47	4.39	2.89	2.52	11.59
E (1977)	.55	2.39	5.58	2.96	3.03	14.51
F (1983)	.84	3.51	7.94	4.00	4.13	20.42
G (1983)	.92	4.02	9.72	4.82	4.90	24.38

TABLE 39 TOTAL ANNUAL COST TO MEET EACH LEVEL OF EFFLUENT REDUCTION

EFFLUENT LEVEL	ANNUAL COST ($ Million) APPLE JUICE	APPLE PRODUCTS	CITRUS PRODUCTS	FROZEN POTATOES	DEHYDRATED POTATOES	TOTAL ANNUAL COST BY LEVEL
B (1977)	.02	.12	.33	.32	.32	1.11
C (1983)	.08	.91	1.40	.74	.78	3.91
D (1977)	.07	.33	1.02	.60	.50	2.52
E (1983)	.02	.09	.34	.23	.22	0.90
F (1983)	.08	.29	.64	.36	.39	1.76
G (1983)	.11	.43	1.01	.54	.58	2.67

ENERGY REQUIREMENTS

Electrical Energy

Electricity is required in the treatment of food processing wastes primarily for pumping and aeration. The aeration horsepower is a function of the waste load and the horsepower for pumping depends on waste water flow rate.

The fruit and vegetable processing industry as a whole is not a large consumer of electrical energy. We estimate that the average power cost per ton of raw material processed is on the order of $0.50, and on this basis the total power bill in 1973 for apple, citrus and potato was about 16,400,000 tons x $0.50/ton or $8,200,000/yr.

Although power requirements for waste treatment systems at some plants may approach 20 percent of the total power consumption, it is estimated that the average contribution of waste treatment systems at apple, citrus and potato processing plants is considerably less than 10 percent of the total at present and should not exceed 10 percent in the future.

Thermal Energy

Thermal energy costs roughly equal electrical energy costs for operations within the industry. Waste treatment systems impose no significant addition to the thermal energy requirement of plants. Wastewater can be reused in cooling and condensing service if it is separated from the process waters in nonbarometric type condensers. These heated waste waters improve the effectiveness of anaerobic ponds which are best maintained at 32°C (90°F) or more. Improved thermal efficiencies are coincidentally achieved within a plant with this technique.

Wastewater treatment costs and effectiveness can be improved by the use of energy and power conservation practices and techniques in each plant. The waste load increases with increased water use. Reduced water use therefore reduced the waste load, pumping costs, and heating costs, the last of which can be further reduced by water reuse as suggested previously.

NON-WATER POLLUTION CONSIDERATIONS

Solid Wastes

The disposal of most of the solid wastes from the fruit and vegetable processing industry is directed toward animal feed. Solid waste consists of cull fruits and vegetables, discarded pieces, and residues from various processing operations. For example, the net energy and total digestible nutrient content of dried potato pulp is very nearly the same as U.S. No. 2 corn. One exception of waste utilization as animal feed occurs when excessive amounts of pesticides have been used during the growing season and the wastes are contaminated. If this is the case, the wastes are then used for fertilizer or land fill.

Screening devices of various designs and operating principles remove large-scale solids such as peel, pulp, cores, and seeds prior to waste water treatment. These solids are then either processed for co-products, sold for animal feed, or land filled.

The solid material, separated during waste water treatment, containing organic and inorganic materials, including those added to promote solids separation, is called sludge. Typically, it contains 95 to 98 percent water prior to dewatering or drying. Some quantities of sludge are generated by both primary and secondary treatment systems with the type of system influencing the quantity. The following table illustrates this:

Treatment System	Sludge Volume as Percent of Raw Wastewater Volume
Dissolved air flotation	Up to 10%
Anaerobic lagoon	(Sludge accumulation in these (lagoons is usually not sufficient to require removal at (any time.
Aerobic and aerated lagoons	
Activated sludge	10 - 15%
Extended aeration	5 - 10%
Anaerobic contact process	approximately 2%

The raw sludge can be concentrated, digested, dewatered, dried, incinerated, land-filled, or spread in sludge holding ponds. In most cases, as stated previously, the sludge goes to animal feed.

Sludge from air flotation with polyelectrolyte chemicals added has proven difficult to dewater, and thereby, presents problems in disposal by any of the aforementioned handling processes. Also, certain polyelectrolyte chemicals rendered the sludge inadequate for animal consumption.

Sludge from secondary treatment systems is normally dewatered or digested sufficiently for hauling and sale as animal feed or fertilizer or for land fill. The final dried sludge material can be safely used as an effective soil builder. Prevention of runoff is a critical factor in plant-site sludge holding ponds. Costs of typical sludge handling techniques for each secondary treatment system generating enough sludge to require handling equipment are already incorporated in the costs for these systems.

Silt water from cleaning root commodities such as potatoes is usually handled separately from the food processing water which goes through secondary treatment. The silt water being relatively free of organic matter goes to silt settling ponds. Silt accumulated in the bottom of the ponds is removed annually and disposed of by adding it to pond dikes. These ponds are generally abandoned after useful performance, with new ponds being established.

In addition to the solid wastes generated as a result of food processing, solid waste is also generated in terms of trash normally associated with activities. This material may be disposed of at the plant site or collected by the local municipality with disposal by incineration or sanitary land fill. The solid wastes or trash comprises packaging materials, shipping crates, and similar dry combustible materials.

Sanitary wastes are usually handled by a separate system in the plant (in most cases municipal) and consequently are not involved in the food processing waste water treatment. The sanitary wastes are of low volume and quite efficiently treated in standard sanitary waste treatment facilities.

Air Pollution

Odors are the only significant air pollution problem related to waste water treatment in the fruit and vegetable canning industry. Fetid conditions usually occur in anaerobic environments within aerobic systems. It is generally agreed, however, that anaerobic ponds will not create serious odor problems unless the process water has a sulfate content. Sulfate waters are a localized condition varying even from well to well in a specific plant. The anaerobic pond odor potential is somewhat unpredictable as evidenced by a few plants that have odor problems without sulfate waters. In these cases a cover and collector of the off-gas from the pond controls odor. The off-gas is then flared. The change in weather in the spring in northern climates may be accompanied by an increase of odor problem.

Other potential odor generators in the waste water treatment are tanks and process equipment for the anaerobic contact process that normally generate methane. However, with the process restricted to a specific piece of equipment it is not difficult to confine and control odors by collecting and flaring the off-gases. These gases' high heating value makes it economical and standard practice to recover the heat for use in the waste water treatment process.

Odors have been produced by some air flotation systems which are normally housed in a building, thus localizing, but intensifying the problem. Minimizing the unneccessary delay of disposal of any skimmings or grease-containing solids has been suggested.

Odors can best be controlled by elimination of conditions that generate odors. Using low sulfate process water, careful screening of waste water to remove organic solids, shallow holding ponds (approximately 0.45 meters optium (1.5 feet), and alkaline pH conditions aid in odor reduction. Also, certain types of bacteria have been found to be particularly well suited to control odor problems. Controls for odors once emanated remain largely unproven at this time.

Other air pollutants such as fog from cooling towers or the pollutants associated with the combustion of fossil fuel are common to all industrial processes are not judged to be significant problems in the food processing industry.

Noise

The only material increase in noise caused by a waste water treatment system is that caused by the installation of an air flotation system or aerated lagoons with air blowers. Large pumps and an air compresser are part of an air flotation system. Such a system is normally housed in a low-cost building; thus, the substantial noise generated by an air flotation system is confined and perhaps amplified by installation practices. All air compressors, air blowers, and large pumps in use on intersively aerated treatment systems, and other treatment systems as well, may produce noise levels in excess of the Occupational Safety and Health Administration standards while the industry should consider these standards in solving its waste pollution problems they are not considered to be serious problems in the food processing industry.

SECTION IX

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

INTRODUCTION

The waste water effluent limitations which must be achieved by July 1, 1977 specify the degree of effluent reduction attainable through the application of the Best Practicable Control Technology Currently Available. Best Practicable Control Technology Currently Available is based upon the average of the best existing performance by plants of various sizes, ages, and unit processes within the industrial subcategory. This average is not based upon a broad range of plants within the canned and preserved fruits and vegetables industry, but based upon performance levels achieved by exemplary plants.

Consideration has, also, been given to the following:

The total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application;

The size and age of equipment and facilities involved;

The processes employed;

The engineering aspects of the application of various types of control techniques;

Process changes;

Non-water quality environmental impact(including energy requirements).

Best Practicable Control Technology Currently Available emphasizes treatment facilities at the end of canning, freezing, or dehydrating process but includes the control technologies within the process itself when the latter are considered to be normal practice within the industry.

A further consideration is the degree of economic and engineering reliability which must be established for the technology to be "currently available." As a result of demonstration projects, pilot plants and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of commencement of construction of the control facilities.

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EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

The waste water effluent limitation guidelines for the apple, citrus and potato segment of the canned and preserved fruits and vegetables industry are based on the information contained in Section III through VIII of this report. This industry segment consists of processors of the following products: apple products (except caustic peeled and dehydrated products); citrus products (except pectin and pharmaceutical products);and all frozen and dehydrated potato products. A determination has been made that the quality of effluent attainable through the application of the Best Practicable Control Technology Currently Available is as listed in Table 40. These guidelines are developed from the average performances of exemplary secondary biological treatment systems (listed in Table 41).

A biological treatment system which is permitted to operate at a constant food to microorganism ratio throughout the year and with minimum operational changes would have a natural variation of 50 percent as explained in Section VII and as demonstrated by the performance of an activated sludge plant at PO-128. A similar system with careful operational control and proper design can be operated within 25 percent of the average on a monthly operating basis. A system without optimum operational control has been used to account for normal treatment variation. Thus, a factor of 50 percent has been used to calculate the maximum 30 day effluent limitation. A further allowance of 100 percent has been applied to a maximum 30 day effluent limitation in order to develop the maximum daily effluent limitation.

Land disposal is widely practiced in the industry and is a highly effective technology for treating wastes from plants processing apples, citrus and potatoes. In the development of the recommended guidelines, serious consideration was given to making land disposal and consequent zero discharge mandatory in all instances where appropriate land is economically available to the processor. The recommended guidelines in Table 40 do not make zero discharge through land disposal mandatory because of the difficulty of defining "economically available". However, land treatment should be selected in cases where suitable land is available.

IDENTIFICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Best Practicable Control Technology Currently Available for the apple (except caustic peeled and dehydrated products) citrus (except pectin and pharmaceutical products) and potato (dehydrated and frozen) processing segments of the canned and preserved fruits and vegetables industry includes preliminary screening, primary settling (potato only) and biological secondary treatment. Strict management control over housekeeping and water use practices can produce a raw waste load as cited in Section V for apples, citrus and potatoes (See Tables 19,20, 21). No special in-plant modification is required.

The stated guidelines for the two apple subcategories can be achieved by applying the Best Practicable Control Technology to the appropriate apple subcategory raw waste load developed in Section V (See Table 19). The Best Practicable Control Technology Currently Available in the apple industry includes screening and secondary biological treatment. The recommended effluent limitation guidelines for 1 July 1977 for the apple products (except juice) subcategory are the average of the exemplary biological treatment systems. The BOD5 effluent limitation is the average of the BOD5 discharge (listed on Table 41) from the secondary biological treatment systems at AP-140, AP-121, AP-108, AP-103, AP-102 and AP-101. The suspended solids effluent limitation is the average of the TSS discharges from AP-140, AP-121, AP-108 and AP-103. The 50 percent factor discussed previously is applied to these BOD5 and TSS annual limits to calculate the maximum thirty day averages (Table 40). The exemplary biological treatment systems used by these plants are activated sludge, anaerobic plus aerobic lagoons, multiple aerated lagoons and trickling filter plus aerated lagoons. The recommended effluent limitation guidelines for 1 July 1977 for the apple juice subcategory are calculated from the apple products effluent limitation with raw waste effluent data from Table 19. The apple juice raw waste BOD is only one-third as large as the apple products BOD and the apple juice suspended solids is only one-half as large as the apple products SS. Thus, the calculated apple juice subcategory limitations are almost one-half the apple products (except juice) subcategory. These limitations are being met by AP-140, AP-121, and AP-103. AP-102 processes apple juice.

TABLE 40

MAXIMUM THIRTY DAY AVERAGE

RECOMMENDED EFFLUENT LIMITATION GUIDELINES FOR 1 JULY 1977

PLANT SUBCATEGORY (1)		BOD$_5$		SUSPENDED SOLIDS	
		kg/kkg	lb/T	kg/kkg	lb/T
APPLES:	Apple Juice	0.30	0.60	0.40	0.80
APPLES:	Apple Products Except Juice	0.55	1.10	0.70	1.40
CITRUS:	Juice, Oil, Segments Peel Products	0.40	0.80	0.85	1.70
POTATOES:	Frozen Products	1.40	2.80	1.40	2.80
POTATOES:	Dehydrated Products	1.20	2.40	1.40	2.80

(1) For all subcategories pH should be between 6.0 and 9.0

The stated guidelines for the citrus subcategory can be achieved by applying the Best Practicable Control Technology to the citrus subcategory raw waste load developed in Section V (See Table 20). The Best Practicable Control Technology Currently Available in the citrus industry includes cooling towers for the recirculation of weak cooling water which is currently segregated from the high BOD wastes which are treated with preliminary screening and secondary biological treatment. The recommended effluent limitation guidelines for 1 July 1977 for the citrus products subcategory are based on the performances of the exemplary biological systems treating citrus wastes. The BOD$_5$ effluent limitation is the maximum BOD$_5$ discharge (listed on Table 41) of the secondary biological treatment systems at CI-127, CI-118, CI-105, CI-106, CI-108, CI-123 and CI-119. The suspended solids effluent limitation is the average of the TSS discharges from CI-127, CI-118, CI-105, CI-106, CI-108, CI-123 and CI-119. The maximum thirty day averages (Table 40) are calculated from these annual averages by applying a factor of 50 percent. The exemplary biological treatment systems used by these plants are activated sludge, anaerobic plus aerobic lagoons, trickling filter plus aerated lagoons, multiple aerated lagoons plus activated sludge and aerated lagoons.

The stated guidelines for the two potato subcategories can be achieved by applying the Best Practicable Control Technology to the appropriate subcategory raw waste load developed in Section V (See Table 21). The Best Practicable Control Technology Currently Available in the potato industry is screening, primary treatment (silt and process water) and secondary biological treatment. The recommended effluent limitation guidelines for 1 July 1977 for the frozen potato products subcategory are based on the performances of the exemplary biological systems treating potato wastes. The BOD_5 effluent limitation is the maximum BOD_5 discharge (listed on Table 41) of the secondary biological treatment systems at PO-110, PO-128 and PO-127. The suspended solids limitation is the maximum TSS discharge from PO-127 and PO-128. The maximum thirty day averages (Table 40) are calculated from these annual averages by applying a factor of 50 percent. The exemplary biological treatment systems used by these plants are activated sludge, trickling filters, and multiple aerated lagoons. The recommended effluent limitation guidelines for 1 July 1977 for the dehydrated potato subcategory are based on the raw waste data in Table 21 and their performances of the exemplary biological systems treating potato wastes. The BOD_5 and suspended solids effluent limitations for dehydrated potato products are less than the limitations for frozen potato products because of the substantial difference in the raw waste loads from the two potato subcategories (Table 21). The BOD_5 limitation for dehydrated potato products is the average of the BOD discharge (listed on Table 41) of PO-110, PO-128 and PO-127. The TSS limitation is the maximum TSS discharge from PO-128 and PO-127. The maximum thirty day averages (Table 40) are calculated from these annual averages by applying a factor of 50 percent. PO-128 processes dehydrated potato products. Both PO-128 and PO-127 are Canadian potato processors.

Thus, the effluent guidelines are presently being achieved by apple, citrus and potato plants in each subcategory by secondary biological treatment. Many other plants are also achieving the guidelines through land treatment. Both spray irrigation and flood irrigation are currently practiced successfully. With this technology and proper management, there is no discharge of pollutants to navigable waters.

RATIONALE FOR THE SELECTION OF
BEST PRACTICABLE CONTROL TECHNOLOGY
CURRENTLY AVAILABLE

Age And Size Of Equipment And Facilities

The industry has generally modernized its plants as new methods that are economically attractive have been introduced. No relationship between age of plant and effectiveness of its pollution control was found. (See Section IV.) Also, size was not a significant factor, even though some plants vary widely in size. Small plants are not mechanized to the extent of some larger plants in the industry; still they are able to achieve at least as effective control as larger plants. This is partly because the small-scale operation permits more options for small low-cost in-plant equipment that are not available to larger operations because of the immense volume of materials concerned.

Total Cost Of Application In Relation To Effluent Reduction Benefits

Based on the information contained in Section VIII of this report, the combined small and large apple, citrus and potato processors must invest $5.47 million (Level B) in construction of biological systems and modifications to existing systems and $11.59 million (Level D) in land and construction of land treatment facilities (See Table 38). If activated sludge is the biological system utilized, the cost could be as high as $14.5 million (Level E) plus land treatment costs. Thus, the total investment cost to achieve the best practicable effluent limitations is approximately $17 million but could be high as $26 million. This $17 million investment amounts to a cost of about $3.40 per annual ton of processing capacity and about 1.4 percent of the estimated industry investment of $1.2 billion.

The cost increase to the consumer would be approximately 2.3 percent of the retail price of the products.

The total U.S. investment does not include costs for processors discharging to municipal sewers, but it does include processors utilizing land treatment.

Engineering Aspects Of Control Technique Applications

The specified level of technology is practicable because it is being practiced by plants in all subcategories with multiple aerated lagoons, activated sludge, anaerobic plus aerobic lagoons, trickling filters, trickling filters plus aerated lagoons or activated sludge plus aerated lagoons. With screening, primary treatment (potato only) and a biological system, 6 apple, 7 citrus, and 3 potato plants are presently achieving a BOD_5 discharge of less than 1 kg/kkg (2 lb/T) and twelve apple, citrus, and potato plants are presently achieving a BOD discharge of less than 0.25 kg/kkg (0.5 lb/T) (See Table 41).

Four apple plants including one juice processing plant are presently meeting the 1977 guidelines for BOD and SS with biological treatment. It must be noted that two biologically treated effluents are not discharged but are disposed of through land treatment systems. Activated sludge, anaerobic plus aerobic lagoons, multiple aerobic lagoons, and trickling filters plus aerated lagoons are the exemplary biological treatment systems.

Five citrus products plants are presently meeting the 1977 guidelines for BOD and SS. Two additional citrus processors are meeting the BOD limitations only. Multiple aerated lagoons, anaerobic/aerobic lagoons, aerated lagoon with trickling filter and activated sludge are the exemplary treatment system. Of these seven plants, five would not require cooling towers or ponds for barometric cooling waters.

Two Canadian potato processing plants are able to achieve high levels of effluent reduction for BOD5 and suspended solids through the utilization of exemplary secondary biological treatment systems. An American potato processing plant is able to achieve high levels of effluent reduction for BOD5. Each of these three secondary biological treatment systems achieve at least the effluent reduction required through the application of Best Practicable Control Technology Currently Available on a seasonal average. The discharge from the secondary biological system treating frozen and dehydrated potato processing wastes from plant PO-128 was able to achieve the effluent reduction required through the application of the Best Practicable Control Technology Currently Available at all times during their 44 week 1972 processing season. Their maximum monthly BOD5 and TSS discharges, which are 1.04 kg/kkg (2.08 lb/ton) and 1.32 kg/kkg (2.63 lb/ton) respectively, are less than the effluent limitations for either frozen or dehydrated potato products. The discharge from the secondary biological system treating frozen potato processing wastes from plant PO-127 has been able to achieve the effluent reduction required through the application of the best practicable technology from December 1972, through December 1973. Their maximum monthly BOD5 and TSS discharges, which are 1.2 kg/kkg (2.4 lb/ton) and 0.55 kg/kkg (1.1 lb/ton) respectively, are less than the effluent limitations for frozen potato products. The exemplary treatment systems are activated sludge, trickling filters, and multiple aerated lagoons. (Another treatment system consisting of anaerobic and aerobic lagoons included in earlier reports was omitted because of inaccurate operating data. With proper management along with reliable quality control, this system may demonstrate that it is exemplary.)

Thus, biological treatment has been shown to be practicable and currently available technology for achieving the 1977 guidelines for the apple, citrus and potato industry. In addition the guidelines can be achieved by land treatment through spray irrigation or flood irrigation or other ultimate disposal technologies as described in Section VII.

TABLE 41

EFFLUENTS FROM SECONDARY TREATMENT SYSTEMS

PLANT CODE	CAPACITY (kkg/D)	BOD5 DISCHARGE (kg/kkg	lb/T)	SS DISCHARGE (kg/kkg	lb/T)
AP-140	50	0.10	0.20	0.23	0.46
AP-121	125	0.15	0.29	0.09	0.18
AP-108	145	0.95	1.90	1.35	2.70
AP-103	170	0.22	0.44	0.04	0.08
AP-102	220	0.07	0.13	----	----
AP-101	235	0.63	1.25	2.40	4.79
CI-127	225	0.05	0.10	0.08	0.16
CI-118	750	0.20	0.39	1.55	3.10
CI-105 (3)	2250	0.05	0.10	0.05	0.10
CI-106	2100	0.25	0.49	0.33	0.66
CI-109	2900	0.05	0.10	0.05	0.10
CI-108	3400	0.04	0.08	1.15	2.30
CI-123	3800	0.05	0.10	0.40	0.80
CI-119	5700	0.19	0.38	0.16	0.31
PO-128 (1)	140	0.70	1.40	0.90	1.80
PO-128 (2)	140	0.10	0.20	0.35	0.70
PO-110	320	0.95	1.90	-	-
PO-127	365	0.60	1.20	0.40	0.80

(1) After screening, primary, activated sludge
(2) After (1) and three aerated lagoons (to receiving waters)
(3) Common treatment system (CI-109)

Approximately 50 percent of the apple plants and apple plant production utilize land treatment to dispose of their wastes. At least 10 additional apple plants are presently achieving an effluent reduction greater than required by the application of the Best Practicable Control Technology Currently Available through land treatment. Approximately 50 percent of the citrus and potato plants and about 50 percent of their production utilize land treatment to dispose of their wastes. Thus, at least 20 additional citrus plants and twelve additional potato plants are currently achieving an effluent reduction greater than required by the application of the Best Practicable Control Technology Currently Available.

Process Changes

No major in-plant changes will be needed by most plants to meet the limits specified. Many plants will need to improve their water conservation practices and housekeeping, both responsive to good plant management control.

Non-Water Quality Environmental Impact

The major impact when the option of a biological type of process is used to achieve the limits will be the problem of sludge disposal. Nearby land for sludge disposal may be needed but in many cases sludge conditioning will allow the sludge solids to be treated and sold as animal feed.

Another problem is the odor that emits periodically from anaerobic lagoons or localized anaerobic environments within aerobic lagoons. The odor problem can usually be avoided with well operated systems and proper in-plant waste management.

There is also a potential detrimental impact on soil systems when application of waste to soil is not managed adequately. Management must assure that land treatment systems are maintained commensurate with crop need and soil tolerance.

Factors To Be Considered In Applying BPCTCA Limitations

1. Land treatment by spray irrigation, or equivalent methods providing minimal discharge should be encouraged.

2. Limitations are based on 30 day averages (See Table 40). Based on performance of biological waste treatment systems at exemplary plants, the maximum daily limitations should not exceed the maximum 30 day average limitations by more than one hundred percent for the apple juice and apple products, citrus products and the frozen and dehydrated potato products subcategories (See Table 42).

3. The nature of biological treatment plants is such that on the order of one week may be required to reach the daily maximum limitation after initial start-up at the beginning of the processing season.
   These values may be omitted when computing average thirty day limitations.

4. If a plant produces products in more than one subcategory, for instance apple juice and apple sauce or frozen and dehydrated

potato products, the effluent limitations should be set by proration on the basis of the percentage of the total raw material being processed to each product.

5. The production basis which is recommended for applying these limitations is the daily average production of the maximum thirty consecutive days.

TABLE 42

MAXIMUM DAILY AVERAGE
RECOMMENDED EFFLUENT LIMITATION
GUIDELINES FOR JULY 1, 1977

PLANT SUBCATEGORY (1)	BOD5		SUSPENDED SOLIDS	
	kg/kkg	lb/T	kg/kkg	lb/T
APPLES: Apple Juice	0.60	1.20	0.80	1.60
APPLES: Apple products except juice	1.10	2.20	1.40	2.80
CITRUS: Juice, Oil, Segment, Peel Products	0.80	1.60	1.70	3.40
POTATOES: Frozen Products	2.80	5.60	2.80	5.60
POTATOES: Dehydrated Products	2.40	4.80	2.80	5.60

(1) For all subcategories pH should range between 6.0 and 9.0 at any time.

SECTION X

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

INTRODUCTION

The effluent limitations which must be achieved no later than July 1, 1983 are not based on an average of the best performance within an industrial subcategory, but are determined by identifying the very best control and treatment technology employed by a specific point source within the industrial category or subcategory, or by one industry where it is readily transferable to another. A specific finding must be made as to the availability of control measures and practices to eliminate the discharge of pollutants, taking into account the cost of such elimination.

Consideration must also be given to:

The age of the equipment and facilities involved;

The process employed;

The engineering aspects of the application of various types of control techniques;

Process changes;

The cost of achieving the effluent reduction resulting from application of the technology;

Non-water quality environmental impact (including energy requirements).

Also, Best Available Technology Economically Achievable emphasizes in-process controls as well as control or additional treatment techniques employed at the end of the production process.

This level of technology considers those plant processes and control technologies which, at the pilot plant, semi-works, or other level, have demonstrated both technological performances and economic viability at a level sufficient to reasonably justify investing in such facilities. It is the highest degree of control technology that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and including "no discharge" of pollutants. Although economic factors are considered in this development, the costs for this

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level of control are intended to be the top-of-the-line of current technology, subject to limitations imposed by economic and engineering feasibility. However, there may be some technical risk with respect to performance and with respect to certainty of costs. Therefore, some industrially sponsored development work may be needed prior to its application.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

The effluent limitation guidelines for the apple, citrus and potato segment of the canned and preserved fruits and vegetables industry are based on the information contained in Section III through VIII of this report. This industry segment consists of processors of the following products; apple products (except caustic peeled and dehydrated products); citrus products (except pection and pharmaceutical products); and frozen and dehydrated potato products. A determination has been made that the quality of effluent attainable through the application of the best available technology economically achievable is as listed in Table 43. The technology to achieve these goals is generally available, although the advanced treatment techniques may not have yet been applied to a processing plant at full scale.

It was pointed out in Section IX that land treatment was a highly effective technology for treating apple, citrus and potato wastes. The considerations of land treatments made in Section IX for 1977 apply here for 1983 alternatives. Where suitable land is available, irrigation is an option that not only is recommended from the discharge viewpoint, but also will usually be more economical than the system otherwise required.

TABLE 43

MAXIMUM THIRTY DAY AVERAGE
RECOMMENDED EFFLUENT LIMITATION GUIDELINES FOR 1 JULY 1983

PLANT SUBCATEGORY(1)	BOD5		SUSPENDED SOLIDS	
	kg/kkg	lb/T	kg/kkg	lb/T
APPLES: Apple Juice	0.10	0.20	0.10	0.20
APPLES: Apple Products Except Juice	0.10	0.20	0.10	0.20
CITRUS: Juice, Oil, Segments and Peel Products	0.07	0.14	0.10	0.20
POTATOES: Frozen Products	0.17	0.34	0.55	1.10
POTATOES: Dehydrated Products	0.17	0.34	0.55	1.10

(1) For all subcategories pH should be between 6.0 and 9.0

(2) For all subcategories most probable number (MPN) of fecal coliforms should not exceed 400 counts per 100 ml.

IDENTIFICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

The best available technology economically achievable for the apple (except caustic peeled and dehydrated products), citrus (except pectin and pharmaceutical products) and frozen and dehydrated potato processing segment of the canned and preserved fruits and vegetables industry includes the preliminary screening, primary settling, and secondary biological treatment listed under the Best Practicable Control Technology Currently Available. In addition, it includes additional secondary treatment such as more aerated lagoons or advanced treatment such as a sand filter following secondary treatment. Disinfection is, also, included.

Management controls over housekeeping and water use practices will be stricter than required for 1977. However, no additional in-plant controls will be required to achieve the specified levels of effluent reduction. The following paragraphs describe several in-plant controls and modifications that provide alternatives and trade-offs between controls and additional effluent treatment. In many cases they are economically more attractive than additional treatment facilities.

1. Recycle of raw material wash water. Solids removal and chlorination are required. This step is presently being practiced at a few potato plants and will soon be practiced in the citrus industry.

2. Utilization of low water usage peel removal equipment. Some of this equipment is being used, such as the rubber abrading and brushing system used for the removal of potato peel.

3. Removal of solids from transport and slicing waters. Hydroclones or liquid cyclones can recover starch particles from potato cutting water and apple particles from apple-slicing waters. The hydroclones can, also, be used to remove solid material from total plant waste waters. Up to 50 percent total BOD removal is possible. The system is presently being used on a limited basis in the potato industry. Its applicability may vary from plant to plant.

4. Improved mechanical cleaning of belts to replace belt wash water.

5. Recirculation of all cooling water through cooling towers or spray ponds. Cooling waters include barometric water, can-cooling water, bottle chilling water, etc.

6. Practice of extensive dry cleanup to replace washing and, where possible, use of continuous dry cleanup and materials recovery procedures. Push-to-open valves need to be used wherever possible. Spray nozzles can be redesigned for lower water flow. Automatic valves that close when the water is not in use should be installed.

The stated guidelines for the two apple subcategories can be achieved by adding aerated lagoons and/or shallow lagoons and/or a sand filter plus disinfection (chlorination) to the best practicable control technology. The recommended effluent limitation guidelines for 1 July 1983 for the apple juice and apple products (except juice) subcategories are based on the performances of the best secondary biological systems treating apple wastes. The BOD_5 effluent limitation is based on the BOD_5 discharge from the treatment system at plant AP-102 and the suspended solids effluent limitation is based on the maximum TSS discharge from the treatment systems at plant AP-121 and AP-103. As described previously, these annual averages are converted to maximum thirty day limitations (Table 43) by applying a factor of 50 percent. The guidelines for the citrus subcategory can be attained through the addition of an anaerobic/aerobic lagoon and shallow lagoon or an aerated lagoon and/or a sand filter plus disinfection (chlorination) to the best practicable control technology currently available. The recommended effluent limitation guidelines for 1 July 1983 for the citrus products subcategory are based on the performances of the best secondary biological systems treating citrus wastes. The BOD5 effluent limitation is based on the average BOD5 discharges (listed on Table 41) from treatment systems at plant CI-127, CI-105, CI-108 and CI-123. The suspended solids limitation is based on the maximum TSS discharge from the treatment systems at plant CI-127 and CI-105. The maximum thirty day averages (Table 43) are calculated from these annual averages by applying a factor of 50 percent. The guidelines for the two potato subcategories can be achieved by adding an aerated lagoon and a shallow lagoon or an aerated lagoon and/or sand filtration plus disinfection (chlorination) to the best practicable control technology. The recommended effluent limitation guidelines for 1 July 1983 for the frozen and dehydrated potato products subcategories are based on the performances of the best secondary biological systems treating potato wastes. The BOD$_5$ effluent limitation is based on the BOD discharge to receiving waters from the treatment system at plant PO-128. The suspended solids limitation is based on the average TSS discharge to receiving waters from treatment systems at plant PO-128 and PO-127. Both PO-128 and PO-127 are Canadian potato processing plants. The maximum thirty day averages (Table 43) are calculated from these annual averages by applying a factor of 50 percent. The guidelines for all five subcategories can also be achieved by land treatment if suitable land is available (See Section IX). Screening and primary treatment (potato only), a shallow mixing lagoon and spray irrigation achieve a minimal waste water discharge.

RATIONALE FOR THE SELECTION OF BEST AVAILABLE CONTROL TECHNOLOGY ECONOMICALLY ACHIEVABLE

Age And Size Of Equipment And Facilities

Neither size nor age was found to affect the effectiveness of the best available technology economically achievable. In-plant control can be managed quite effectively in older plants even though the technologies required for reducing the raw waste loads to low levels may be more costly to install in older plants. For example, rerouting of sewers to segregate waste streams could be difficult and costly.

The smaller operations have more low cost in-plant waste water reduction alternatives than larger plants where immense quantities of materials are involved. It is anticipated that many small plants will find land disposal the best alternative. Municipal treatment is, also, an alternative in many cases.

Total Cost Of Application In Relation To Effluent Reduction Benefits

Based on information contained in Section VIII of this report, the industry as a whole would have to invest about between $5.9 and $11.7 million above that required to meet the 1977 standards. This investment is in new construction of secondary biological or advanced waste treatment facilities. The total investment cost including land and land treatment costs to achieve the best practicable effluent limitations (Section IX) ranged from $17 to $26 million. The total investment cost including land to achieve the best practicable and best available effluent limitations is $29 to $36 million. This $12.7 million investment to achieve the best available effluent reduction amounts to a cost of approximately $2.30 per annual ton of processing capacity and approximately 1.0 percent of the estimated industry investment of $1.2 billion. The combined cost of the best practicable and the best available technology amounts to a cost of between $5.70 and $7.20 per annual ton of processing capacity and between 2.4 percent and 3.0 percent of the estimated industry investment.

The cost to the consumer would be about 1.6 percent of the retail price of the products to achieve best available technology only or the cost for both best practicable and best available technology would be between 3.8 percent and 4.8 percent of the retail price of the products.

All plants discharging to streams can implement the best available technology economically achievable; the technology is not affected by different processes used in the plants.

Engineering Aspects Of Control Technique Application

The specified level of technology is achievable. Biological secondary treatment is practiced throughout the apple, citrus and potato industry and sand filtration is practiced in at least one potato plant (England). With present biological treatment systems without advanced treatment methods such as sand filtration, at least one apple, citrus or potato plant in each of the five subcategories is presently achieving the high levels of effluent reduction required by the application of the Best Available Control Technology Economically Achievable (See Table 41). For example, the maximum monthly discharges from the biological treatment system at PO-128 are 0.14 kg/kkg (0.28 lb/ton) of BOD_5 and 0.50 kg/kkg (1.00 lb/ton) of TSS; these values are less than the effluent limitations for potato processing (Tabel 43).

No unique in-plant control technology is required to achieve these standards. However, many of the in-plant controls outlined above under "Identification of the Best Available Technology Economically Achievable" have been utilized to achieve high levels of effluent reduction. An apple sauce, slice, and juice plant has a raw waste BOD of 1.4 kg/kkg (2.8 lb/T) compared to the average of over 5 kg/kkg (10 lb/T) (See Table 19). A citrus juice, oil and feed processing plant has a water usuage of only 710 l/kkg (170 gal/T), BOD of 0.45 kg/kkg (0.9 lb/T) and suspended solids of 0.02 kg/kkg (0.04 lb/T). These values compare with average flow values of 10,110 l/kkg (2425 gal/T), average BOD of 3.2 kg/kkg (6.4 lb/T) and average SS of 1.3 kg/kkg (2.6 lb/T) See Table 20). A frozen potato procesor has a water usage of 4,090 l/kkg (980 gal/T) and a BOD of 4.45 kg/kkg (8.9 lb/T) compared with average values of 11,320 l/kkg (2710 gal/T) and 22.9 kg/kkg (45.86 lb/T) (See Table 21). Thus, in-plant controls exist as alternatives to additional secondary biological treatment.

There is an additional 50 percent of the industry that is presently using land treatment. Thus, over 40 plants are presently achieving effluent reductions required by 1983 guidelines and many have no discharge of pollutants to navigable waters. This technology is used with and without holding ponds in Idaho, Washington, California, Pennsylvania, Virginia, New York and Florida. Most other states also have land treatment of the fruit and vegetable industry. Application of technology for greatly reduced water use will facilitate land disposal. Experience has shown that good management practices assure that land disposal and irrigation systems can be maintained commensurate with crop need and soil tolerance.

Process Changes

No in-plant changes will be needed by most plants to meet the limits specified. Some available techniques which may be economically attractive are outlined in the "Identification of the Best Available Technology Economically Achievable," paragraph above.

Non-Water Quality Environmental Impact

The non-water quality impacts will essentially be those described in Section IX. It is concluded that nc new serious impacts will be introduced.

Factors To Be Considered In Applying Level II Guidelines

1. Land treatment by spray irrigation, or equivalent methods providing minimal discharge should be encouraged.
2. Limitations are based on 30 day averages (See Table 43). Based on performance of biological waste treatment systems at exemplary plants, the maximum daily limitations should not exceed the maximum 30 day average limitations by more than one hundred percent for the apple juice and apple products, citrus products and frozen and dehydrated potato products subcategories (See Table 44).
3. The nature of biological treatment plants is such that on the order of one week may be required to reach the daily maximum limitations

after initial start-up at the beginning of the processing season. These values may be omitted when computing average thirty day limitations.

4. If a plant produces products in more than one subcategory, for instance, apple juice and apple sauce or frozen and dehydrated potato products, the effluent limitations should be set by proration on the basis of the percentage of the total raw material being processed to each product.

TABLE 44

MAXIMUM DAILY AVERAGE
RECOMMENDED EFFLUENT LIMITATION
GUIDELINES FOR JULY 1, 1983

PLANT SUBCATEGORY (1)	BOD5		SUSPENDED SOLIDS	
	kg/kkg	lb/T	kg/kkg	lb/T
APPLES: Apple Juice	0.20	0.40	0.20	0.40
APPLES: Apple products except juice	0.20	0.40	0.20	0.40
CITRUS: Juice, Oil, Segment, Peel Products	0.14	0.28	0.20	0.40
POTATOES: Frozen Products	0.34	0.68	1.10	2.20
POTATOES: Dehydrated Products	0.34	0.68	1.10	2.20

(1) For all subcategories pH should range between 6.0 and 9.0 at any time.

(2) For all subcategories must probable number (MPN) of fecal coliforms should not exceed 400 counts per 100 ml.

SECTION XI

NEW SOURCE PERFORMANCE STANDARD

INTRODUCTION

The effluent limitations that must be achieved by new sources are termed performance standards. The New Source Performance Standards apply to any source for which construction starts after the publication of the proposed regulations for the Standards. The Standards are determined by adding to the consideration underlying the identification of the Best Practicable Control Technology Currently Available a determination of what higher levels of pollution control are available through the use of improved production processes and/or treatment techniques. Thus, in addition to considering the best in-plant and end-of-process control technology, New Source Performance Standards are based on an analysis of how the level of effluent may be reduced by changing the production process itself. Alternative processes, operating methods or other alternatives are considered. However, the end result of the analysis is to identify effluent standards which reflect levels of control achievable through the use of improved production a particular (as well as control technology), rather than prescribing a particular type of process or technology which must be employed. A further determination made is whether a standard permitting no discharge of pollutant is practicable.

Consideration must also be given to:

Operating methods;

Batch, as opposed to continuous, operations;

Use of alternative raw materials and mixes of raw materials;

Use of dry rather than wet processes (including substitution of recoverable solvents for water);

Recovery of pollutants as by-products.

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EFFLUENT REDUCTION ATTAINABLE FOR NEW SOURCES

The effluent limitation for new sources is the same as that for the best available technology economically achievable (see Section X). This limitation is achievable in newly constructed plants.

The in-plant controls and waste treatment technology identified in Section X are available now and applicable to new plants. Land disposal remains the most desirable disposal method. The land availability requirements for treatment can be considered in site selection for a new plant. Thus, land treatment will probably be the most attractive new source alternative.

The new source technology is the same as that identified in Section X. The conclusion reached in Section X with respect to Total Cost of Application in Relation to Effluent Reduction Benefits, the Engineering Aspects of Control Technique Application, Process Changes, Non-Water Quality Environmental Impact, and Factors to be Considered in Applying Level II Guidelines, apply with equal force to these New Performance Standards.

PRETREATMENT REQUIREMENTS

Large quantities of three constituents of the waste water from plants within the apple, citrus or potato processing industry have been found which could interfere with, pass through, or, otherwise, be incompatible with a well designed and operated publicly owned activated sludge or trickling filter waste water treatment plant. Waste water constituents include caustic solutions from peeling operations such as lye dip potato peelers, D'limonene from citrus peel processing operations, and oil from frying operations. Adequate control methods can and should be used to keep significant quantities of these materials out of the waste water.

SECTION XII

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SECTION XIII

REFERENCES

BOOKS

1. Besselievre, Edmund B., *The Treatment of Industrial Wastes*, McGraw-Hill Book Co., New York, 1969.

2. Culp, Russell L. and Culp, Gordon L., *Advanced Wastewater Treatment*, Van Nostrand Reinhold Company, New York, 1971.

3. Eckenfelder, W. Wesley, Jr., *Industrial Water Pollution Control*, McGraw-Hill Book Co., New York, 1966.

4. Eckenfelder, W. Wesley, Jr., *Water Quality Engineering for Practicing Engineers*, Barnes and Noble, Inc., New York, 1970.

5. Fair, Gordon M., Geyer, John C., and Okun, Daniel A., *Water and Wastewater Engineering, Vol. 2, Water Purification and Wastewater Treatment and Disposal*, John Wiley & Sons, Inc., New York 1968.

6. Lock, Arthur, *Practical Canning*, 3rd Edition, Food Trade Press, London, 1969.

7. Mancy, K. H. and Weber, W. J., Jr., *Analysis of Industrial Wastewater*, John Wiley & Sons, New York, 1971.

8. Talburt, William F. and Smith, Ora, *Potato Processing*, 2nd Edition, The AVI Publishing Co., Inc., Westport, Connecticut, 1967.

9. Tressler, Donald K. and Joslyn, Maynard A., *Fruit and Vegetable Juice Processing Technology*, 2nd Edition, The AVI Publishing Co., Inc., Westport, Connecticut, 1971.

10. Weber, Walter J., Jr., *Physicochemical Processes for Water Quality Control*, John Wiley & Sons, Inc., New York, 1972.

11. *Agricultural Statistics 1972*, United States Department of Agriculture (USDA), U. S. Government Printing Office, Washington, D.C., 1972.

Preceding page blank

12. The Almanac of the Canning, Freezing, and Preserving Industries 1972, 57th Edition, Edward E. Judge and Sons, Inc., Westminster, Maryland.

13. The Almanac of the Canning, Freezing, and Preserving Industries 1971, 56th Edition, Edward E. Judge and Sons, Inc., Westminster, Maryland.

14. 1972 Annual Book of ASTM Standards, Part 23, Water; Atmospheric Analysis, American Society for Testing and Materials, Philadelphia, Pennsylvania.

15. Canners Directory 1969-70, National Canners Association, Washington, D.C.

16. The Directory of the Canning, Freezing, and Preserving Industries 1972-73, 4th Biennial Edition, Edward E. Judge and Sons, Inc., Westminster, Maryland, 1972.

17. Frozen Food Pack Statistics 1972, American Frozen Food Institute, Washington, D.C.

18. Standard Industrial Classification Manual 1972, Executive Office of the President, Office of Management and Budget, Statistical Policy Division, Washington, D.C.

19. Standard Methods for the Examination of Water and Wastewater, 13th Edition, American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D.C. 1971.

20. Water Quality and Treatment, The American Water Works Association, Inc., 3rd Edition, McGraw-Hill Book Co., New York.

PUBLICATIONS

1. Allen, Thomas S. and Kingsbury, Robert P., The Physiological Design of Biological Towers, 28th Annual Purdue Industrial Waste Conference, May 2, 1973.

2. Cochrann, M. W., Burn, R. J., and Dostal, K. A., Cannery Wastewater Treatment with Rotating Biological Contactor and Extended Aeration, Pro. Element 1 B2037, EPAORM, USGPO, Washington, D.C., April 1973.

3. Dostal, K.A., Aerated Lagoon Treatment of Food Pro-

cessing Wastes, EPAWQO, Project No. 12060, USGPO, Washington, D.C., March 1968.

4. Dostal, K. A., *Secondary Treatment of Potato Processing Wastes*, EPAWQO, Project No. 12060, USGPO, Washington, D. C., July 1969.

5. Eckenfelder, W. W., Jr., Woodward, Charles, Lawler, John, and Spinna, Robert, *Study of Fruit and Vegetable Processing Waste Disposal Methods in the Eastern Region*, USDA, Contract No. 12-14-100-482 (73), September 1958.

6. Eilero, R. G. and Smith, R., *Wastewater Treatment Plant Cost Estimating Program*, EPAWQO, Cincinnati, Ohio, April 1971.

7. Esvelt, L. A., *Aerobic Treatment of Fruit Processing Wastes*, Federal Water Pollution Control Administration, USDI, Grant No. 12060, October 1969.

8. French, R. T., Company, *Aerobic Secondary Treatment of Potato Processing Wastes*, EPAWQO, Project No. 12060, EHV, WPRD 15-01-68, Washington, D. C., December 1970.

9. Guttormsen, K. and Carlson, D. A., *Current Practice in Potato Processing Waste Treatment*, FWPCA, USDI, Grant No. WP-01486-01, October 1969.

10. Law, J. P., et al. *Nutrient Removal From Cannery Wastes by Spray Irrigation of Grassland*, FWPCA, USDI, Water Pollution Control Research Service 16080, Washington, D.C., November 1969.

11. Mercer, W. A. and Somers, I. I., *Chlorine in Food Plant Sanitation*, Western Research Lab., National Canners Association (NCA), Berkeley, California.

12. Stevens, Michael R., Elazar, Daniel J., and Schlesinger, Jeanne, *Green Land-Clean Streams*, Center for the Study of Federalism, Temple University, Philadelphia, Pennsylvania, 1972.

13. Winter Garden Citrus Products Cooperative, *Complete Mix Activated Sludge Treatment of Citrus Process Wastes*, EPAORM, Grant No. 12060, EZY, Washington, D.C., August 1971.

14. Gallup, James D., *Investigation of Filamentous Bulking in the Activated Sludge Process*, University of Oklahoma, Norman, Oklahoma, August, 1971.

SECTION XIV

GLOSSARY

The definitions given herein are not intended to be complete and exact scientific or engineering definitions, but are correct as generally used or understood in the Food Processing Industry.

Acid: Mostly citric acid in citrus fruit; expressed as percent by weight or milligrams per 100 ml.

Activated Sludge: Sludge floc produced in raw or settled waste water by the growth of bacteria and other organisms in the presence of dissolved oxygen and accummulated in sufficient concentration by returning floc previously formed.

Activated Sludge Process: A biological waste water treatment process in which a mixture of waste water and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated waste water (mixed liquor) by sedimentation and wasted or returned to the process as needed.

Aeration: The bringing about of intimate contact between air and waste water by bubbling air through the liquid, mechanically agitating the liquid to promote surface absorption of air, or spraying the waste water in the air.

Aerator: A device used to promote aeration. Typically of a motor driven propeller design; however, many types are available.

Aerobic: Living or active only in the presence of free oxygen.

Air Pollution: The presence in the atmosphere of one or more air contaminants in quantities, of characteristics, and of a duration, injurious to human, plant, animal life, or property, or which unreasonably interfered with the comfortable enjoyment thereof.

Algae: Major group of lower plants, single and multi-celled, usually aquatic and capable of synthesizing their foodstuff by photosynthesis.

Alkalinity: The capacity of water to neutralize acids, a property imparted by the water's content of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates, It is expressed in milligrams per liter of equivalent calcium carbonate.

Anaerobic: Living or active in the absence of free oxygen.

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Barometric Condenser: A type of condenser which allows vapors to be condensed at a pressure of less than one atmosphere. Because it has a long vertical bottom pipe, the pipe is often called a barometric leg.

Biological Filter: A bed of gravel, broken stone, special plastic, or other medium through which waste water flows or trickles and is stabilized by the biological action of bacteriological growths living on the filter media. Also called a trickling filter.

Biological Oxidation: The process whereby, through the activity of living organisms in an aerobic environment, organic matter is converted to more biologically stable matter.

Biological Stabilization: Reduction in the net energy level or organic matter as a result of the metabolic activity of organisms, so that further biodegradation is very slow.

Biological Treatment: Organic waste treatment in which bacteria and/or biochemical action are intensified under controlled conditions.

Blowdown: A discharge from a system, designed to prevent a buildup of some material, as in a boiler to control dissolved solids.

BOD: Biochemical Oxygen Demand (BOD 5-day). The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, (usually 5 days), at a specified temperature, and under specified conditions.

Brix: A scale for indicating percent sugar by weight in a juice or solution. 10° Brix = 10 percent sugar by weight.

Carbon Adsorption: The separation of small waste particles and molecular species, including color and odor contaminants, by attachment to the surface and open pore structure of carbon granules or powder. The carbon is usually "activated", or made more reactive by treatment and processing.

Category and Subcategory: Divisions of a particular industry which possess different traits that affect raw waste water quality.

Caustic: Capable of destroying or eating away by chemical action. Applied to strong bases such as NaOH.

Centrifuge: A mechanical device in which centrifugal force is used to separate solids from liquids and/or separate liquids of different densities.

Chemical Precipitation: A waste treatment process whereby substances dissolved in the waste water stream are rendered insoluble and form a solid phase that settles out or can be removed by flotation techniques.

Chlorination: The addition of minute amounts of chlorine to water or treated waste water to kill bacteria contained therein.

Citrus Pulp (Dried) Citrus Peel (Dried): Chopped peel, seeds and other non-juice parts of the fruit that have been limed and dried for cattle feed.

Clarification: The process of removing undissolved materials from a liquid. Specifically, removal of solids either by settling or filtration.

Clarifier: A settling basin for separating settlable solids from waste water.

Cm: Centimeter.

Coagulant: A material, which, when added to liquid wastes or water, creates a reaction which forms insoluble floc particles that adsorb and precipitate colloidal and suspended solids. The floc particles can be removed by sedimentation. Among the most common chemical coagulants used in sewage treatment are ferric sulfate and alum.

Coagulation: The destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical or by biological process.

COD: Chemical oxygen demand. Its determination provides a measure of the oxygen demand equivalent of that portion of matter in a sample which is susceptible to oxidation by a strong chemical oxidant. Obtained by reacting the organic matter in the sample with oxidizing chemicals under specified conditions.

Cold Pressed Oil: Essential oil from citrus peel obtained without the use of heat.

Coliform bateria: Bacteria perdominantly inhabiting the intestines of man or animal, but occasionally found elsewhere. Their presence in water is evidence of contamination by fecal material.

Completely Mixed Activated Sludge: Treatment system in which the untreated waste water is instantly mixed throughout the entire aeration basin.

Cooling Tower: A device for cooling water by spraying in the air or trickling over slats.

Countercurrent: Flow of wash or process water in opposition to flow of product so that the product encounters increasingly cleaner water.

Cull: Product rejected because of inferior quality.

Deaeration: Removal of oxygen from products (juices or apple slices) to prevent adverse effects on properties of the products.

Decant Water: Water from which a top layer of D-limonene is skimmed off, obtained usually from molasses evaporator condensate (citrus process).

Denitrification: The process involving the facultative conversion by anaerobic bacteria of nitrates into nitrogen and nitrogen oxides.

De-oiling: Removal of oil from produce juices.

De-sludge: A centrifuge designed to remove the coarse particles from a peel oil emulsion.

Detention Time: Period of time required for a liquid to flow through a tank or unit.

Digestion: The biological decomposition of organic matter in sludge, resulting in partial gasification, liquefaction, and mineralization.

Disintegrate: To break or reduce into component parts or particles, e.g., the rupture of potato cells for starch processing.

Dissolved Air Flotation: A process involving the compression of air and liquid, mixing to super-saturation, and releasing the pressure to generate large numbers of minute air bubbles. As the bubbles rise to the surface of the water, they carry with them small particles that they contact. The process is particularly effective for grease removal.

D-limonene: Major constituent of peel oil. Sometimes used synonymously with stripper oil.

Drain-tile: Pipes of various materials with perforations or open joints laid in underground trenches and fills to collect and carry off subsurface water.

Effluent: Wastewater or other liquid, partially or completely treated or untreated, flowing out of a process operation, processing plant, reservoir, basin, or treatment plant.

Electrodialysis: A physical separation process which uses membranes and applied voltages to separate ionic species from water.

Enzyme: A catalyst produced by living cells that accelerates specific transformation of material, as in the digestion of food.

Essential Oil: The oil in citrus peel, peel oil.

Eutrophication: Applies to lake or pond - becoming rich in dissolved nutrients, with seasonal oxygen deficiencies.

Evaporative Condensers: Equipment used to condense hot vapors wherein water is circulated over coils containing the vapors. Part of the water evaporates in the air, enhancing the cooling effect.

Evaporator: Equipment used to remove water from juice or press liquor, usually by boiling in a vacuum, and condensing the vapors.

Evapotranspiration : Water withdrawn from the soil by evaporation and plant transpiration.

Exhaust: Heating of food in cans prior to closing the cans to force air out of the containers.

Extended Aeration: A form of the activated sludge process except that the retention time of waste waters is one to three days.

Facultative Bacteria: Bacteria which can exist and reproduce under either aerobic or anaerobic conditions.

Facultative Decomposition: Decomposition of organic matter by facultative microorganisms.

Facultative Pond: A combination aerobic-anaerobic pond divided by loading and thermal stratification into aerobic surface, and anaerobic bottom, strata.

Feed: A material which flows into a containing space or process unit.

Fermentation: Changes in organic matter brought about by microorganisms growing in the absence of air.

Filtrate: Liquid after passing through a filter.

Filtration: Removal of solid particles from liquid or particles from air or gas stream by passing the liquid or gas stream through a permeable membrane.

Floc: A mass formed by the aggregation of a number of fine suspended particles.

Flocculation: The process of forming larger masses from a large number of finer suspended particles.

Floc Skimmings: The flocculent mass formed on a quieted liquid surface and removed for use, treatment, or disposal.

Fluming: In-plant transportation of product or waste material through water conveyance.

Industrial Wastewater: Flow of waste liquids from industries using large volumes of water from processing industrial products, such as food processing plants.

Influent: A liquid which flows into a containing space or process unit.

Ion Exchange: A reversible chemical reaction between a solid and a liquid by means of which ions may be interchanged between the two. It is in common use in water softening and water deionizing.

Kg: Kilogram or 1,000 grams, metric unit of weight.

Kjeldahl Nitrogen: A measure of the total amount of nitrogen in the ammonia and organic forms in waste water.

KWH: Kilowatt-hours, a measure of total electrical energy consumption.

Lagoon: A large pond used to hold waste water for stabilization by natural processes.

Leach: To subject to the action of percolating water or other liquid in order to separate soluble components. To cause water or other liquid to percolate through.

Leaching: The removal of soluble constituents from soils or other materials by percolating water.

Lime: Calcium oxide, a caustic white solid, which forms slaked lime (calcium hydroxide) when combined with water. It is used for pH control and other waste treatment pruposes.

Lye: A strong alkaline solution. Caustic soda (sodium hydroxide) is the most common lye.

Lye Dump: The spent water from the lye bath that is used to remove the inner membrane of sectionizing fruit. The spent lye solution is discharged periodically.

Lye Rinse: The rinse water used to remove from the fruit, lye solution carried out of the lye bath in sectionizing operations.

M: Meter, metric unit of length.

Make-up Water: Fresh water added to process water to replace system losses.

Mean: The average value of a number of observed data.

MGD: Million gallons per day.

Mg/l: Milliongrams per liter; approximately equals parts per million; a term used to indicate concentration of materials in water.

Microstrainer/microscreen: A mechanical filter consisting of a cylindrical surface of metal filter fabric with openings of 20-60 micrometers in size.

Mixed Liquor (ML): A mixture of sludge and waste water in a biological reaction tank undergoing biological degradation in an activated sludge system.

Molasses: A dark-colored syrup containing non-sugars produced by evaporating press liquor and other strong wastewater to about 70 percent dissolved solids. Molasses is used as commercial cattle feed or in the manufacture of monosodium glutamate, a food flavoring agent, alcohol, yeast, citric acid and other products.

mm: Millimeter = 0.001 meter.

Municipal Treatment: A city or community-owned waste treatment plant for municipal and, possibly, industrial waste treatment.

Neutralize: To adjust the pH of a solution to 7.0 (neutral) by the addition of an acid or a base.

Nitrate, Nitrite: Chemical compounds that include the NO - (nitrate) and NO - (nitrite) ions. They are composed of nitrogen and oxygen, are nutrients for growth of algae and other plant life, and contribute to eutrophication.

Nitrification: The process of oxidizing ammonia by bacteria into nitrites and nitrates.

No Discharge: No discharge of effluents to a water course. A system of land disposal with no runoff or total recycle of the waste water may be used to achieve it.

Non-Water Quality: Thermal, air, noise and all other environmental parameters except water.

Nutrients: Compounds that promote biological growth, e.g., phosphorus and nitrogen. Usually undesirable in treated effluent; however, they are required in proper proportions for successful biological waste treatment.

Organic Content: Synonymous with volatile solids except for small traces of some inorganic materials such as calcium carbonate which will lose weight at temperatures used in determining volatile solids.

Oxidation Lagoon: Synonymous with aerobic or aerated lagoon.

Oxidation Pond: Synonymous with aerobic lagoon.

Oxygen Uptake Rate: Oxygen utilization rate or rate at which oxygen is used by bacteria in the decomposition of organic matter.

Peak Flow: The highest average daily flow occurring throughout a period of time.

Percolation: The movement of water through the soil profile.

pH: A measure of the relative acidity or alkalinity of water. A pH value of 7.0 indicates a neutral condition; less than 7 indicates a predominance of acids, and greater than 7, a predominance of alkalis. There is a 10-fold increase (or decrease) from one pH unit level to the next, e.g., 10-fold increase in alkalinity from pH 8 to pH 9.

Polisher: A centrifuge designed to separate peel oil from its emulsion.

Pollutant: A substance which taints, fouls, or otherwise renders impure or unclean the recipient system.

Pollution: The presence of pollutants in a system sufficient to degrade the quality of the system.

Polyelectrolyte Chemicals: High molecular weight substances which dissociate into ions when in solution; the ions either being bound to the molecular structure or free to diffuse throughout the solvent, depending on the sign of the ionic charge and the type of electrolyte. They are often used as flocculation agents in waste water treatment, particularly along with dissolved air flotation.

Pomace: Pulpy substance of fruit and vegetables after grinding and juicing.

Ponding: A waste treatment technique involving the actual holdup of all waste waters in a confined space with evaporation and percolation the primary mechanisms operating to dispose of the water.

Ppm: Parts per million, a measure of concentration, expressed currently as mg/l.

Precipitation: The phenomenon that occurs when a substance held in solution in a liquid passes out of solution into solid form.

Press Liquor: The liquid obtained when citrus peel is chopped, treated with lime, and pressed or squeezed.

Pretreatment: Wastewater treatment located on the plant site and upstream from the discharge to a municipal treatment system.

Primary Waste Treatment: In-plant by-product recovery and waste water treatment involving physical separation and recovery devices such as catch basins, screens, and dissolved air flotation.

Process: A series of actions or operations conducted to an end.

Process Effluent or Discharge: The volume of water emerging from a particular use in the plant.

Process Water: Water which is used in the internal juice streams from which sugar is ultimately crystallized.

Proteinase: An enzyme which hydrolyzes proteins.

Raw Ton: One ton of unprocessed commodity.

Raw Waste: The waste water effluent from the in-plant primary waste treatment system.

Recycle: The return of a quantity of effluent from a specific unit or process to the feed stream of that same unit. This would also apply to return of treated plant waste water for several plant uses.

Representative Sample: A sample of the same composition as the thing it represents.

Retort: The heating of canned foods after closing to sterilize the product.

Reverse Osmosis: The physical separation of substances from a water stream by reversal of the normal osmotic process; i.e., high pressure, forcing water through a semi-permeable membrane to the pure water side leaving behind more concentrated waste streams.

Sand Filter: A filter device incorporating a bed of sand that, depending on design, can be used in secondary or tertiary waste treatment.

Scalder Discharge: Hot water used to soften the peel of fruit before sectionizing.

Scalding: Treatment with steam at high temperatures.

Screening: The removal of relatively coarse floating and suspended solids from waste water by straining through racks and screens.

Secondary Treatment: The waste treatment following primary in-plant treatment, typically involving biological waste reduction systems.

Sedimentation: The falling or settling of solid particles in a liquid, as a sediment.

Semipermeable Membrane: A thin sheet-like structure which permits the passage of solvent but is impermeable to dissolved substances.

Settleable Solids: Suspended solids which will settle in sedimentation basins (clarifiers) in normal detention times.

Settling Tank: Synonymous with "Sedimentation Tank".

Sewage: Water after it has been fouled by various uses. From the standpoint of source it may be a combination of the liquid or water-carried wastes from residences, business buildings, and institutions, together with those from industrial and agricultural establishments, and with such groundwater, surface water, and storm water as may be present.

Shock Load: A quantity of waste water or pollutant that greatly exceeds the normal discharged into a treatment system, usually occurring over a limited period of time.

Sizing: The process of cutting and trimming the product.

Sludge: (1) The accumulated solids separated from liquids, such as water or waste water, during processing, or deposits on bottoms of streams or other bodies of waters. (2) The precipitate resulting from chemical treatment, coagulation, or sedimentation of water or waste water.

Slurry: A mixture of water with finely divided suspended solids.

Solute: A dissolved substance.

Sour: Term used to signify waste water treatment systems that have a low pH value. The acid condition is favorable to growth of organisms which produce foul smelling by-products, hence is undesirable.

Standard Deviation: A measure of the variation of data values around the mean.

Stoichiometric Amount: The amount of a substance involved in a specific chemical reaction, either as a reactant or as a reaction product.

Strength: The relative total concentration in effluent of BOD, COD, TSS (albuminoids, amino acids, pectins and sugars), alkalinity and acidity.

SS: Suspended Solids. (1) Solids that either float on the surface of, or are in suspension in water, waste water, or other liquids, and which are largely removable by laboratory filtering. (2) The quantity of material removed from waste water in a laboratory test, as prescribed in "Standard Methods for the Examination of Water and Wastewater" and referred to as nonfilterable residue.

Stripper Oil: Mostly d-limonene obtained from molasses evaporator condensate by decantation.

Substrate: Raw waste feed on which a microorganism grows or is placed to grow by decomposing the waste material.

Substrate Removal: The total BOD in plant effluent, minus the soluble BOD in plant effluent, divided by the total influent BOD.

Sulfiting: Exposing sized fruit to sulfur dioxide atmosphere or solution for stabilizing color, flavor, and texture.

Supernatant: The layer floating above the surface of a layer of solids.

Surcharge: An additional service charge imposed upon industry by a municipality for discharge of waste water to the municipal sewer system in excess of some previously specified volume and/or character.

Surface Water: The waters of the United States including the territorial seas.

Syrup: Water solution of sugar, usually sucrose.

Tertiary Waste Treatment: Waste treatment systems used to treat secondary treatment effluent and typically using physical-chemical technologies to effect waste reduction. Synonymous with "Advanced Waste Treatment".

Total Dissolved Solids (TDS): The total amount of dissolved material, organic and inorganic, contained in water or wastes. Excessive dissolved solids can make water unsuitable for industrial uses and unpalatable for drinking.

TOC: Total organic carbon. A test expressing waste water contaminant concentration in terms of the carbon content.

Total Suspended Solids (TSS): See Suspended Solids.

Trickling Filter: See Biological Filter.

Vector: A carrier of pathogenic organisms.

APPENDIX A

APPLES - INFORMATION FROM PROCESSING PLANTS

Plant Code	Plant kkg/hr	Capacity (T/hr)	Products	Method of Treatment
AP-101	29.02	32.0	Sauce & Juice	Aerated Lagoon
AP-102	27.21	30.0	Sauce & Juice	Land Disposal Spray Irrigation after Secondary Treatment
AP-103	21.41	23.6	Sauce, Juice & Vinegar	Land Disposal Spray Irrigation after Secondary Treatment
AP-104	13.61	15.0	Sauce & Slices	Land Disposal Spray Irrigation
AP-105	20.41	22.5	Sauce, Slices & Juice	Land Disposal Spray Irrigation
AP-106	24.31	26.8	Slices & Vinegar	
AP-107	15.87	17.5	Sauce & Juice	
AP-108	18.14	20.0	Sauce, Slices & Juice	
AP-109	-	-	Slices	Lagoons
AP-110	-	-	Sauce	
AP-111	4.08	4.5	Pie Filling	Municipal Sewer
AP-112	2.72	3.0	Slices	Land Disposal Irrigation
AP-113	7.26	8.0	Slices & Sauce	Municipal Sewer
AP-114	43.08	47.5	Sauce, Juice & Vinegar	Land Disposal Irrigation
AP-115	13.97	15.4	Sauce & Juice	Land Dispodal Spray Irrigation & Municipal Sewer
AP-116	38.91	42.9	Sauce & Juice	Land Disposal Spray Irrigation
AP-117	25.94	28.6	Slices, Sauce, Juice & Vinegar	Land Disposal Spray Irrigation
AP-118	1.36	1.5	Slices	Municipal Sewer
AP-119	-	-	Sauce & Juice	
AP-120	-	-	Sauce	
AP-121	15.9	17.5	Sauce	Aerated Lagoons
AP-122	4.54	5.0	Sauce	Land Disposal Spray Irrigation
AP-123	21.77	24.0	Slices & Sauce	Land Disposal Spray Irrigation
AP-124	20.41	22.5	Juice	Municipal Sewer
AP-125	-	-	Sauce	Land Disposal Ponds
AP-126	8.61	9.5	Slices & Sauce	Municipal Sewer
AP-127	-	-	Slices	Municipal Sewer

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(Continued)
APPLES - INFORMATION FROM PROCESSING PLANTS

Plant Code	Plant Capacity kkg/hr	(T/hr)	Products	Method of Treatment
AP-128		4.1	Sauce	Municipal Sewer
AP-129	4.54	5.0	Vinegar	Land Disposal Irrigation
AP-130	3.63	4.0	Sauce	Land Disposal Irrigation
AP-131	-	-	Dehydrated Pieces	Land Disposal System
AP-132	5.44	6.0	Sauce & Juice	Aseptic Pond (Closed)
AP-133	4.54	5.0	Juice	Aseptic Pond (Closed)
AP-134	4.99	5.5	Sauce	Municipal Sewer
AP-135	4.08	4.5	Slices	Municipal Sewer
AP-136	-	-	Juice	Municipal Sewer
AP-137	1.81	2.0	Slices & Juice	Municipal Sewer
AP-138	4.54	5.0	Slices & Dices	Municipal Sewer
AP-139	31.00	34.2	Sauce, Slices & Juice	Municipal Sewer
AP-140	6.36	7.0	Slices	Activated Sludge
AP-141	12.50	13.8	Juice	Municipal Sewer
AP-142	10.88	12.0	Dehydrated Slices	Municipal Sewer

CITRUS - INFORMATION FROM PROCESSING PLANTS

Plant Code	Plant Capacity		Products	Method of Treatment
	kkg/D	(T/D)		
CI-101	145.8	160.5	Juice, Oil/Peel-Pulp By-Products	Municipal Sewers
CI-102	1,229.0	1,335.0	Juice, Oil/Peel-Pulp By-Products,	Land Disposal Irrigation & Ocean Brine Line
CI-103	317.5	350.0	Juice, Oil/Peel-Pulp By-Product, Pectin/Pharmaceuticals	Land Disposal Irrigation
CI-104	1,133.8	1,250.0	Juice, Segments	Aerated Tanks, Clarifier, Trickling Filter
CI-105	2,267.5	2,500.0	Juice, Oil/Peel-Pulp By-Products	Aerated Lagoon & Land Disposal Irrigation
CI-106	2,086.1	2,300.0	Juice, Oil/Peel-Pulp By-Products	Aeration, Clarification
CI-107	1,088.4	1,200.0	Juice, Oil	Land Disposal Irrigation
CI-108	3,412.1	3,762.0	Juice, Segments, Oil/ Peel-Pulp By-Products	Activated Sludge Land Disposal Irrigation
CI-109	2,875.1	3,150.0	Juice, Oil/Peel-Pulp By-Products	Aerated Lagoon & Land Disposal Irrigation
CI-110	2,875.1	3,150.0	Juice, Oil/Peel-Pulp By-Products	Municipal Sewer & Land Disposal Irrigation
CI-111	1,836.8	2,025.0	Juice, Oil/Peel-Pulp By-Products	Lagoons, Land Disposal Irrigation
CI-112	326.5	360.0	Juice	Municipal Sewer
CI-113	3,673.4	4,050.0	Juice, Segments, Oil/ Peel-Pulp By-Products	Municipal Sewer
CI-114	2,448.9	2,700.0	Juice, Oil/Peel-Pulp By-Products	Land Disposal Irrigation
CI-115	1,836.8	2,025.0	Juice, Oil/Peel-Pulp By-Products	Land Disposal Irrigation

(Continued)

(Continued)

CITRUS - INFORMATION FROM PROCESSING PLANTS

Plant Code	Plant Capacity kkg/D	(T/D)	Products	Method of Treatment
CI-116	1,224.5	1,350.0	Juice, Peel-Pulp By-Products	Municipal Sewer
CI-117	571.4	630.0	Juice, Oil/Peel-Pulp By-Products	Land Disposal Irrigation
CI-118	743.7	820	Juice, Segments Peel-Pulp By-Products	Aerated Lagoons
CI-119	5,714.1	6,300.0	Juice, Oil/Peel-Pulp By-Products	Aerated Lagoons
CI-120	308.4	340.0	Juice, Oil/Peel-Pulp By-Products	No Treatment
CI-121	3,174.5	3,500.0	Juice, Oil/Peel-Pulp By-Products	Land Disposal Irrigation
CI-122	1,020.4	1,125.0	Juice, Oil	Land Disposal Irrigation, Municipal Sewer
CI-123	3,809.4	4,200.0	Juice, Oil/Peel-Pulp By-Products	Aeration, Clarification
CI-124	408.2	450.0	Juice	Municipal Sewer
CI-125	29.0	32.0	Segments	Municipal Sewer
CI-126	5,079.2	5,600.0	Juice, Peel-Pulp By-Products	No Treatment
CI-127	226.8	250.0	Segments	Trickling Filter, Aeration
CI-128	285.7	315.0	Juice, Oil/Peel-Pulp By-Products	Land Disposal Irrigation
CI-129	1,732.4	1,910.0	Juice, Segments, Oil/ Peel-Pulp By-Products	Activated Sludge
CI-130	1,142.8	1,260.0	Juice, Segments, Oil	Land Disposal Irrigation
CI-131	689.3	760.0	Juice, Oil, Pectin	Land Disposal Irrigation & Oil Brine Line
CI-132	453.5	500.0	Juice, Oil	Municipal Sewer

(Continued)

(Continued)
CITRUS - INFORMATION FROM PROCESSING PLANTS

Plant Code	Plant Capacity kkg/D	(T/D)	Products	Method of Treatment
CI-133	1,020.4	1,125.0	Juice, Oil	No Treatment
CI-134	-	-	Juice, Oil	Municipal Sewer
CI-135	-	-	Peel-Pulp By-Products	-
CI-136	530.6	585.0	Juice, Oil/Peel-Pulp	Land Disposal Irrigation
CI-137	86.2	95.0	Juice, Oil	Municipal Sewer
CI-138	127.0	140.0	Juice	Municipal Sewer
CI-139	-	1,100.0	Juice, Oil/Peel-Pulp By-Product	Land Disposal Irrigation
CI-140	-	-	Juice	Land Disposal Irrigation
CI-141	-	-	Juice, Peel-Pulp By-Products	Aerobic & Anaerobic Digestion Municipal Sewer
CI-142	-	-	Juice, Oil	Land Disposal Irrigation
CI-143	-	-	Juice, Peel-Pulp By-Products	Land Disposal Irrigation
CI-144	-	-	Juice, Oil/Peel-Pulp By-Products	Land Disposal Irrigation
CI-145	-	-	Juice	Municipal Sewer
CI-146	-	-	Segments	Municipal Sewer Land Disposal Irrigation
CI-147	-	-	Peel-Pulp By-Products	Land Disposal Irrigation
CI-148	-	-	Juice, Segments	Municipal Sewer
CI-149	-	-	Juice, Oil	Municipal Sewer

POTATOES - INFORMATION FROM PROCESSING PLANTS

Plant Code	Plant Capacity kkg/D	(T/D)	Products	Method of Treatment
PO-101	1,133.8	1,250	French Fries, Dehydrated Flakes & Granules	Activated Sludge & Land Disposal Spray
PO-102	1,633.6	1,800	French Fries, Dehydrated Flakes & Granules	Activated Sludge & Land Disposal Spray
PO-103	544.2	600	French Fries	Activated Sludge
PO-104	435.4	480	Dehydrated Products	-
PO-105	-	-	Dehydrated Products	-
PO-106	-	-	French Fries	-
PO-107	544.2	600	Dehydrated Granules & Slices	Activated Sludge
PO-108	634.9	700	French Fries	Activated Sludge
PO-109	1,043.1	1,150	French Fries	Activated Sludge
PO-110	317.5	350	French Fries & Hash Browns	Aerated Lagoon
PO-111	725.6	800	French Fries & Potato Wedges	Land Disposal Spray Irrigation
PO-112	907.0	1,000	French Fries, Hash Browns & Dehydrated Flakes	Land Disposal Ponds

(Continued)

(Continued)
POTATOES - INFORMATION FROM PROCESSING PLANTS

Plant Code	Plant Capacity kkg/D	Plant Capacity (T/D)	Products	Method of Treatment
PO-113	498.9	550	Dehydrated Granules	Land Disposal Spray Irrigation
PO-114	453.5	500	Dehydrated Granules	Land Disposal Flood Irrigation
PO-115	217.7	240	Dehydrated Flakes	Activated Sludge Land Disposal Spray Irrigation
PO-116	453.5	500	Frozen French Fries	Municipal Sewer
PO-117	562.3	620	Frozen French Fries	Land Disposal Spray Irrigation
PO-118	127.0	140	Frozen French Fries	Activated Sludge
PO-119	72.6	80	Frozen French Fries	Activated Sludge
PO-120	272.1	300	Frozen French Fries	Aerated Lagoons
PO-121	272.1	300	Dehydrated	Municipal Sewer
PO-122	340.1	375	Dehydrated	Land Disposal Spray Irrigation
PO-123	226.8	250	Dehydrated	Anaerobic Pond
PO-124	294.8	325	Dehydrated	Municipal Sewer
PO-125	340.1	375	Frozen French Fries	River
PO-126	90.7	100	Starch	Land Disposal Spray Irrigation
PO-127	453.5	500	Frozen French Fries	Activated Sludge, Aerated Lagoon
PO-128	136.1	150	Frozen French Fries & Dehydrated Products	Trickling Filter
PO-129	181.4	200	Frozen French Fries	Aerobic Lagoon

(Continued)
POTATOES - INFORMATION FROM PROCESSING PLANTS

Plant Code	Plant Capacity kkg/D	(T/D	Products	Method of Treatment
PO-130	544.2	600	Frozen French Fries	Land Disposal Spray Irrigation
PO-131	362.8	400	Frozen French Fries	Land Disposal Spray Irrigation
PO-132	430.8	475	Dehydrated Granules	Land Disposal Spray Irrigation
PO-133	163.3	180	Dehydrated Flakes	Land Disposal Spray Irrigation
PO-134	45.4	50	Sealed Plastic Bag	Aerated Lagoons
PO-135	312.9	345	Dehydrated Flakes	Municipal Sewer
PO-136	589.6	650	Dehydrated Flakes, Granules & Dices	Activated Sludge Land Disposal Spray

APPLES - PRODUCT CLASSIFICATION BY SIC CODE

SIC PRODUCT CODE	PRODUCT
2033	Canned Fruits and Vegetables
0 00	For companies with 10 or more employees
0 02	For companies with less than 10 employees
1	Canned Fruits (except baby foods)
1 12	Apples, excluding pie mix
1 13	Applesauce - 372 gm. to 511 gm. (13.1 oz. to 18 oz.)
1 14	Applesauce - other sizes
1 61	Canned fruit pie mix - apple
4	Canned fruit juices & concentrates
4 11	Apple juice
4 85	Fruit juices, concentrated, hot pack - 116 gm. to 119 gm.(4.1oz. to 7oz.)
4 89	Fruit juices, concentrated, hot pack - Other sizes and bulk
4 91	Fruit juices, fresh, to be kept under refrigeration
2034	Dehydrated Fruits and Vegetables and Soup Mixes
0 00	For companies with 10 or more employees
0 02	For companies with less than 10 employees
1	Dried fruits and vegetables, except soup mixes
1 21	Apples
2037	Frozen Fruits and Vegetables
0 00	For companies with 10 or more employees
0 02	For companies with less than 10 employees
1	Frozen fruits, juice and ades
1 55	Apples and applesauce
1 95	Apple frozen fruit juice concentrate

Source: Standard Industrial Classification Manual (1972, Office of Management and Budget, Government Printing Office)

CITRUS - PRODUCT CLASSIFICATION BY SIC CODE

SIC PRODUCT CODE	
2033	Canned Fruits and Vegetables
0 00	For companies with 10 or more employees
0 02	For companies with less than 10 employees
1	Canned Fruits (except baby foods)
1 31	Grapefruit Segements
1 34	Fruit for Salad - Citrus
4	Canned Fruit Juices & Concentrates
4 31	Grapefruit Juice
4 42	Orange Juice Single Strength 1.14 kg to 1.7 kg (40.1 oz. to 60 oz.)
4 43	Orange Juice Single Strength Other Sizes
4 51	Grapefruit-Orange Juice Blend
4 53	Grapefruit-Pineapple Juice Blend
4 85	Fruit Juices, Concentrated, Hot Pack (116 gm to 119 gm (4.1 oz. to 7 oz.)
4 89	Fruit Juices, Concentrated, Hot Pack Other Sizes and bulk
4 91	Fruit Juices, Fresh, to be kept under refrigeration
2037	Frozen Fruits and Vegetables
0 00	For companies with 10 or more employees
0 02	For companies with less than 10 employees
1	Frozen Fruits, Juices and Ades
1 81	Orange Juice-116 gm to 199 gm (4.1 oz. to 7 oz.)
1 82	Orange Juice-287 gm to 369 gm. (10.1 oz. to 13 oz.)
1 83	Orange Juice - Other Sizes
1 85	Lemonade-116 gm to 199 gm (4.1 oz. to 7 oz.)
1 86	Lemonade-287 gm to 369 gm (10.1 oz. to 13 oz.)
1 87	Lemonade - Other Sizes

Source: _Standard Industrial Classification Manual_ (1972)
Office of Management and Budget, Government
Printing Office

POTATOES - PRODUCT CLASSIFICATION BY SIC CODE

SIC PRODUCT CODE	PRODUCT
2033	Canned Fruits and Vegetables
0 00	For companies with 10 or more employees
0 02	For companies with less than 10 employees
2	Canned Vegetables (except hominy and mushrooms)
2 74	White potatoes
2034	Dehydrated Fruits and Vegetables and Soup Mixes
0 00	For companies with 10 or more employees
0 02	For companies with less than 10 employees
1	Dried Fruits and Vegetables, Except Soup Mixes
1 31	Potatoes - consumer size - 454 gm. (1 lb) and under.
1 35	Potatoes - commercial size - over 454 gm. (1 lb)
2037	Frozen Fruits and Vegetables
0 00	For companies with 10 or more employees
0 02	For companies with less than 10 employees
2	Frozen Vegetables
2 47	Potatoes & Potato Products (french fried patties, puffs, etc.)
2046	Wet corn milling - Potato Starch
2099	Food Preparations, Not Elsewhere Classified - Potato Chips

Source: Standard Industrial Classification Manual (1972)
Office of Management and Budget, Government Printing Office

DATA SUMMARY

APPLE PROCESSING

1. Average Daily Plant Processing Capacity

Tons of Fruit/Hr. ____________

2. Plant Categorization

Canned

a. Sliced _____%

b. Sauce _____%

Frozen

a. Sliced _____%

b. Diced _____%

c. Sauce _____%

Dehydrated

a. Sliced _____%

b. Diced _____%

Juice

a. Cider or Juice _____%

b. Vinegar Stock _____%

Total 100%

3. Process Equipment

Type of Peeling	________________	Type of Coring	________________
Manufacturer	________________	Manufacturer	________________
Type of Slicing	________________	Type of Finishing	________________
Manufacturer	________________	Manufacturer	________________

DATA SUMMARY

CITRUS PROCESSING

1. Average Daily Plant Processing Capacity

Tons of Fruit/Day ______________

2. Plant Categorization

a. Single Strength Juice __________

b. Chilled Juice __________

c. Chilled Segments __________

d. Concentrated Juice __________

Total 100%

e. Oranges __________

f. Grapefruit __________

g. Lemons and Limes __________

Total 100%

WASTE EFFLUENT DATA

3. In-Plant & Post Treatment (End-of-Pipe) Waste Effluents

Line No.	Gal/Min	Percent Recycled	BOD	COD	Temp. °F	pH	Total Solids	Suspended Solids
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

See page No. Three for additional Line Nos.

DATA SUMMARY

POTATO PROCESSING

1. Average Daily Plant Processing Capacity

   Location of Plant ______________________________

   Tons of Potatoes/Day __________

2. Plant Categorization

   a. Frozen

      French Fries __________

      Hash Browns __________

      Preformed Shapes __________

   b. Dehydrated

      Granules __________

      Flakes __________

      Chips __________

      Cubes __________

   c. Canned

      Whole __________

      Sliced __________

   d. Other

      ______ __________

____

Total 100%

DATA SUMMARY - APPLE PROCESSING

WASTE EFFLUENT DATA

4. In-Plant & Post Treatment (End-of-Pipe) Waste Effluents

Line No.	Gal/Min	Percent Recycled	BOD	COD	Temp. °F	pH	Total Solids	Suspended Solids
1								
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3								
4								
5								
6								
7								
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42								
43								
44								
45								

5. Settling Ponds

Number ________ Total Area ________ Total Volume _______

6. Screening Equipment

Type __________ Mesh Opening _______ Screen Area ________

7. Clarifier

Number ________ Type _______________ Size ________

8. Rotary Vacuum Filters

Number ________ Type _______________ Size ________

9. Aeration Ponds

Number ________ Total Area ________ Size ________

10. Land Disposal

Type __________ Total Area ________

11. Discharge to Municipal Sewer

Daily, Monthly or Yearly Assessment and Basis of Calculating the Assessment ______________________________

12. River and/or Stream

Name ____________________________________

ECONOMIC DATA

13. Construction Cost of Waste Treatment Facility (include laboratory)

14. Operating Cost of Waste Treatment Facility (include laboratory)

Volatiles in Citrus Wastes: Those constituents that can distill over in an evaporator and collect in the condensate. Chiefly peel oil constituents and essence from juice.

CONVERSION TABLE

MULTIPLY (ENGLISH UNITS) by conversion factor to obtain METRIC UNITS

ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION
acre	ac	0.405	ha
acre - feet	ac ft	1233.5	cu m
British Thermal Unit	BTU	0.252	kg cal
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg
cubic feet/minute	cfm	0.028	cu m/min
cubic feet/second	cfs	1.7	cu m/min
cubic feet	cu ft	0.028	cu m
cubic feet	cu ft	28.32	liters
cubic inches	cu in	16.39	cu cm
degree Fahrenheit	F°	0.555(°F-32)*	°C
feet	ft	0.3048	m
gallon	gal	3.785	liters
gallon/minute	gpm	0.0631	l/sec
horsepower	hp	0.7457	kw
inches	in	2.54	cm
inches of mercury	in Hg	0.03342	atm
pounds	lb	0.454	kg
million gallons/day	mgd	3,785	cu m/day
mile	mi	1.609	km
pound/square inch (gauge)	psig	(0.06805 psi +1)*	atm
square feet	sq ft	0.0929	sq m
square inches	sq in	0.452	sq cm
tons (short)	t	0.907	kkg
yard	y	0.9144	m

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* Actual conversion, not a multiplier

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